# REPORT
# SUPPLEMENTAL GEOTECHNICAL ENGINEERING INVESTIGATION
# SENECA LANE MUDSLIDE
# SEWER STABILIZATION STUDY
# APN: 041-090-160
# SAN MATEO COUNTY, CALIFORNIA

for
**BKF Engineers**

**March 2018**

BAGG ENGINEERS

Geotechnical ▸ Geoenvironmental ▸ Special Inspection

March 1, 2018
BAGG Job No: BKFEN-34-00

Mr. Yousef Moradzadeh
BKF Engineers
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Redwood City, California 94065

**Supplemental Geotechnical Engineering Investigation**
Seneca Lane Mudslide
Sewer Stabilization Project
San Mateo County, California

Dear Mr. Moradzadeh:

Transmitted herewith is our supplemental geotechnical engineering investigationreport for the captioned project in San Mateo County, California. The report combines the findings of the original investigation as well as the data from the most recent investigation regarding the soil and bedrock conditions at the project location;and our revised recommendations as they pertain to mitigation of the mudslide and stabilization of the sewer line.

Thank you for the opportunity to perform these services. Please do not hesitate to contact us, should you have any questions or comments.

Very truly yours,
**BAGG Engineers**

Michael Matusich
Senior Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER MICHAEL MATUSICH GE 3013 EXP. 12/31/18 GEOTECHNICAL STATE OF CALIFORNIA

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**For BKF Engineers**

## 1.0 INTRODUCTION

This report presents the results of our supplemental geotechnical engineering investigation performed for thesewer line stabilization studynorth of 1560 Seneca Lane in San Mateo County, California. The attached Plate 1, Vicinity Map, shows the general location of the site, and Plate 2, Site Plan depicts the sewer line layout, a rough outline of the mudslide impacting the sewer line, and the approximate locations of our exploratory borings (old as well as the recent) drilled for this investigation. Our initial geotechnical engineering investigation was performed in general accordance with our proposal No. 17-245 datedMay31, 2017, and our supplemental geotechnical engineering investigation was performed in general accordance with our proposal No. 17-699 dated December 19, 2017.

## 2.0 SITE DESCRIPTION

The site is located downslope of the residential property of 1560 Seneca Lane, San Mateo County, California. The site is near the top of an approximately400-foot-tall, northwest-draining, hillside which trends from Seneca Lane down to San Mateo Creek at an average gradient of about 2.5 horizontal to 1 vertical. The residence backyard at 1560 Seneca Lane slopes downhill for about 50 feet at a gradient of about 2H:1V to an unpaved access road which had recently been impacted by a mudslide that occurred during the winter of 2016/2017. The subject underground sewer main was located within the access road and the mudslide removed a portion of the access road and sewer line. The scarp of the initial mudslide extended more or less to the inboard edge of the roadway and impacted about 60 feet of roadway and sewer line. The mudslidebelow the roadway is up to approximately 120 feet in width, trends downslope for about 200 feet in length, and narrows in width at its toe which encroaches on an abandoned trail located downslope. In the latter part of Winter 2016/2017, another smaller mudslide occurred about 40 feet upslope from the previous mudslide, damaging the temporary pipe and pump system for the damaged sewer line and requiring additional maintenance and monitoring to ensure the functionality of sewer main.

We noted a damaged corrugated metal storm drain pipe protruding from the west side of the scarp as shown on Plate 2, Site Plan. The pipe is believed to be connected to a catch basin at the back side of the access road where it collects drainage from the upslope area through a concrete linedV-ditch.

The mudslide area is currently only accessible by foot through the backyard of the residential property located at 1560 Seneca Lane. Vehicular access was once possible via the impacted access road which trends roughly east to west along the side of the hillside and then southward to Bunker Hill Road, about a mile or so from the site. Some rather large erosion gullies have developed along the route, narrowing the roadway such that vehicular access to the site area is not possible at the present time.

## 3.0 PROJECT DESCRIPTION

The subject project will consist of restoring gravity flow through the impacted portion of the sewer line and the limited repair of the mudslide impacted area to restore the original section of the access road. Mitigation measures may consist of construction of a new soldier pier and lagging type retaining wall to restore the original width of the access road. A new sewer line will be placed behind the retaining wall and gravity flow will be restored. Site grading is anticipated to consist of removal of soft/loose material associated with the slide to firm ground, placement of engineered fill behind the wall to restore the original grades of the access road andgrading of the limited area behind the wall to blend in with surrounding terrain.

BAGG conducted a preliminary geotechnical investigation consisting of drilling five borings (Borings B-1 thru B-5) to depths ranging from 3 to 14 feet and extending through the mudslide mass and into weathered bedrock in May, 2017. A Geotechnical Engineering Report presenting the findings from our subsurface exploration, a reconnaissance of the site and immediate vicinity by our Engineering Geologists, laboratory testing results, and providing conclusions and recommendations regarding restoring gravity flow within the damaged sewer main and mitigation of the existing mudslide were presented in our geotechnical report dated September 14, 2017.

## 4.0 PURPOSE AND SCOPE OF SERVICES

The purpose of our supplemental geotechnical engineering investigation was to establish the depth and the lateral extent of the mudslide within the area where the original sewer line was damaged. Samples of the materials (soil/rock) below the mudslide were collected to perform laboratory testing and assess the strength characteristics of the underlying undisturbed soil and bedrock material. The mudslide profile and the soil/rock strength values were used to develop design recommendations for the retaining wall.

Our supplemental geotechnical investigation included a geologic reconnaissance of the site and surrounding area by a Registered Geologist, review of available geologic maps and seismic literature pertinent to the site and surrounding vicinity, exploration of the subsurface soil/rock conditions by drilling three (3) additional borings for a total of 8 borings, collection of soil and bedrock samples for laboratory testing, and performance of laboratory tests on selected soil and bedrock samples to estimate shear strengths. Information obtained from these tasks was then used to perform engineering analyses required to develop conclusions, opinions, and recommendations regarding:

- the depth and lateral extent of the mudslide in the area of the impacted sewer line,including the consistency of the mudslide materials, the consistency and strength characteristics of the soil and/or bedrock beneath the mudslide, and groundwater conditions and their potential impact on the project,
- recommendations for soldier pier and lagging retaining wall and tie-backs, if necessary;
- general recommendations for grading, including utilizing on site soils, keyway width and embedment, and subdrainage;
- general provisions for the proper control of surface and subsurface drainage at the site;

Based on our understanding of the proposed project, the scope of our services consisted of the following specific tasks:

- Research and review pertinent geotechnical and geological maps and reports relevant to the site area regarding the local soil, bedrock and groundwater conditions of the site and vicinity.
- Perform an engineering geologic reconnaissance of the site and prepare a site plan containing the findings of the reconnaissance.
- Mark the drilling locations and notify Underground Service Alert two working days prior to drilling rig mobilization, as required by law.
- Coordinate with and provide appropriate notification to San Mateo County Department of Environmental Health for the drilling of our borings in conjunction with our annual geotechnical drilling permit with San Mateo County.
- Drill three additional borings (B6, B7, and B8) with a portable minuteman rig to practical refusal. Borings B-1 (14 feet), B-2 (14 feet), B-3 (14 feet), B-6 (10 feet), B-7 (9 feet), B-8 (8.5 feet) extended through fill material/slide debris into Franciscan Formation rocks. Borings B-4 and B-5, werelocated within the mudslide scarp where weathered Franciscan Formation Serpentinite was exposed at shallow depths below the existing ground surface, thus these borings were advanced with hand auguring and sampling equipment to depths of about 3 feet. The exploration

wasdirected by one of our geologists, who also maintained a continuous log of the materials encountered, collected soil and bedrock samples for visual examination and laboratory testing, and noted where groundwater was encountered. When completed, the borings were sealed with neat cement grout per standard protocol.

- Perform laboratory testing of selected samples of the soil and bedrock materialsin order to evaluate their engineering characteristics. Tests included direct shearstrength testsatin situ and artificially increased moisture contents, Atterberg Limits testing, and moisture/density measurements, as judged appropriate.
- Perform engineering analysis based on information obtained from the above tasksto develop conclusions, opinions, and recommendations oriented toward the above purposes of our investigation.
- Prepare a report summarizing our findings and including a vicinity map, a site plan, cross section, remedial cross section, regional geologic map, regional fault map, boring logs, and the results of our laboratory testing, as well as our conclusions, opinions, and recommendations for the proposed project.
- Provide engineering consultation services to other project team members during the design phase of the project.

## 5.0 FIELD EXPLORATION AND LABORATORY TESTING

A preliminary geotechnical investigation consisting of drilling five borings (Borings B-1 thru B-5) to depths ranging from 3 to 14 feet and extending through the mudslide mass and into weathered bedrock in May, 2017. The approximate locations of the borings drilled as a part of our preliminary subsurface exploration are shown on the attached Plate 2, Site Plan. Borings B-1 through B-3 were advanced with a portable minuteman drilling rig by Access Soil Drilling, Inc. Boring B-1 was advanced into undisturbed ground near the top of the scarp of the more recent smaller mudslide and encountered serpentinite bedrock at a depth of approximately 10 feet below the existing ground surface. Borings B-2 and B-3 were advanced through the upper portion of the mudslide mass and encountered serpentinite and greenstone bedrock at depths of approximately 8 feet below the surface of the mudslide mass. Borings B-4 and B-5 were advanced with hand auger and sampling equipment into the scarp of the mudslide where undisturbed native material was exposed.

Our supplemental geotechnical engineering investigation consisted of advancing three additional borings (B-6, B-7, and B-8)with a portable minuteman rig and/or by continuous sampling to practical refusal depths ranging from approximately 8½ to 10 feet below the existing ground surface on December 28, 2017.The approximate locations of the borings drilled as a part of our preliminary and supplementary subsurface explorations are shown on the attached Plate 2, Site Plan. Boring B-6 was advanced through the upper eastern portion of the mudslide mass and encountered sandstone bedrock at a depth of approximately 8½ feet below the surface of the mudslide mass. Boring B-7 was advanced into undisturbed ground within the existing access road immediately west of the mudslide scarp and encountered greenstone bedrock at a depth of approximately 6 feet below the existing ground surface. Boring B-8 was advanced within the existing access road approximately 160 feet southwest of the existing mudslide to provide information regarding the soil and bedrock conditions beneath the existing access road. Boring B-8 encountered Franciscan Formation Mélange at a depth of approximately 6 feet below the existing ground surface.

A Modified California (MC) sampler, California samplerand a Standard Penetration Test (SPT) sampler were driven into the subsurface materials with a 140-pound hammer with a 30-inch free fall using a cathead and pulley system for borings B-1 through B-3 and B-6 through B-8. The MC sampler was fitted with brass rings in borings B-1, B-4,B-5, B-6, B-7, and B-8 to allow for laboratory testing of the site subsurface materials obtained. No liners were used in Boring B-2 and B-3 which were stored in core boxes for visual observation by a Certified Engineering Geologist for better evaluation of the mudslide characteristics. The brass ring samples were tested in the laboratory for direct shear strength at artificially increased moisture content, Atterberg Limits, and for moisture/density measurements.

The graphical representation of the materials encountered in the borings, and the results of laboratory tests as well as explanatory/illustrative data are attached, as follows:

- Plate 7, Unified Soil Classification System, illustrates the general features of the soil classification system used on the boringlogs.
- Plate 8, Soil Terminology, lists and describes the soil engineering terms used on the boring logs.
- Plate 9, Rock Terminology, lists and describes the engineering geologic terms used on the boring logs.
- Plate 10, Boring Log Notes, describes general and specific conditions that apply to the boring logs.
- Plate 11, Key to Symbols, describes various symbols used on the boring logs.
- Plates 12 through 19, Boring Logs, describe the subsurface materials encountered, show the depths and blow counts for the samples, and summarize results of the strength tests and moisture-density data.

## 6.0 GEOLOGY AND SEISMICITY

### 6.1 Geology

Based on a review of the *Geologic Map of the Montara Mountain and San Mateo 7-1/2' Quadrangles, San Mateo County, California, U.S. Geological Survey Miscellaneous Investigations Series Map I-2390, by E.H. Pampeyan, 1994*, the site area ispartially underlain by artificial fill ($Qf_1$) overlying bedrock of the Franciscan Complex consisting ofsandstone (fs), greenstone(fg) to the northwest and Serpentinite (sp) mapped to the south-southeast. These geologic formations are described by Pampeyan, (1994) as follows:

***Qf1*** ***Artificial fill - Unit 1*** *(Holocene): Poorly consolidated to well-consolidated gravel, sand, silt, and rock fragments in various combinations used in a variety of applications including riprap, highway-, railroad-, and airport runway-fills, earthfill dams, reservoir embankments, and building site grades. Thickness and consolidation dependent upon type of application and site. Includes organic and man-made debris in sanitary landfills and spoil from tunneling operations. Many small fills not shown because of map-scale limitations.*

***fs*** ***Franciscan Complex Sandstone*** *(Cretaceous and Jurassic): Medium- to coarse-grained, poorly sorted, locally tuffaceous sandstone (lithic graywacke) with interbedded siltstone, shale, and sparse coal. Well indurated, hard, and dark greenish-gray when fresh; weakly indurated, soft, and grayish-orange when weathered. Most natural exposures are deeply weathered, but locally graywacke forms bold outcrops owing to a higher degree of induration or cementation. West of the San Andreas Fault most graywacke occurs in a crudely layered sequence with Franciscan greenstone; east of San Andreas Fault graywacke typically occurs as tectonic inclusions in a matrix or sheared rock (fsr) but also is interlayered with chert (fc). As mapped, unit may locally include sheared rock (fsr).*

***fg*** ***Franciscan Complex Greenstone*** *(Cretaceous and Jurassic): Dark green to red, altered basaltic volcanic rocks, including flows, pillow lava, breccia, tuff, and minor related intrusive rock. Friable to hard and dense depending upon rock type and degree of weathering. West of the San Andreas Fault most greenstone occurs in discrete lenticular units interlayered with Franciscan sandstone (fs); east of the San Andreas Fault greenstone occurs mainly as rounded tectonic inclusions in a matrix of sheared rock (fsr).*

***fsr*** ***Sheared rock*** *(Cretaceous and Jurassic): Predominantly soft, light- to dark-gray, sheared shale, siltstone, and graywacke containing various-size tectonic inclusions of Franciscan rock types. Weathers to grayish-yellow clayey and silty sand and in places is eroded to form badlands topography. Area of outcrop may be greater than shown and may include some areas labeled as sandstone (fs). Slopes underlain by sheared rock unit are unstable, especially when wet. Thickness unknown but more than several hundreds of feet. Commonly referred to as mélange in the California Coast Ranges.*

***sp*** ***Serpentinite*** *(Cretaceous and Jurassic): Soft sheared serpentinite enclosing blocks of hard gray to greenish-gray unsheared serpentinite and ultramafic rocks. West of San Andreas Fault occurs as near vertical tabular bodies in or along faults or shear zones; east of San Andreas Fault occurs largely as flat-lying sheets overlying other Franciscan rocks and as small, near vertical tabular bodies.*

The site location is shown in relation to the geologic map by Pampeyan, 1994, used as a base, on Plate 5.

### 6.2 Seismic Setting

The site and the San Francisco Bay Area lie within the Coast Ranges geomorphic province, a series of discontinuous northwest trending mountain ranges, ridges, and intervening valleys characterized by complex folding and faulting. These faults are in a zone that extends from just off the Pacific Coast through the SanFrancisco Bay area to the western side of the Great Valley. The entire San Francisco Bay region has one of the highest rates of seismic moment release per square mile of any urban area in the United States. It is emerging from the stress shadow of the 1906 SanFrancisco Earthquake and future large earthquakes are considered a certainty.

The subject site is not situated within the limits of the Alquist-Priolo Earthquake Fault Zone (AP Zone) established by the California Geological Survey (CGS) around active faults, where detailed evaluation and characterization of fault activity and potential for ground surface rupture is required. However, the State of California seismic hazard zone maps relevant to the site are not yet available.

The three-major northwest-trending earthquake faults that are part of the San Andreas fault system and extend through the Bay Area include the San Andreas fault, the Hayward fault, and the Calaveras fault which are located about 1 km to the west, approximately 29 km east-northeast, and about 41 km east-northeast of the site, respectively.

While the subject site is not within the Alquist-Priolo Earthquake Fault Zone designated by the California Geological Survey, the San Andreas fault is believed to be the principal seismic hazards in this area because of its activity rate and proximity to the site. The Working Group on California Earthquake Probabilities (2013) has estimated that the probability for a major earthquake ($M_W$ 6.7 or greater) within 30 years on the nearby San Andreas fault is about 33 percent and about 32 percent on the Hayward fault. They also estimate there is a 72% chance there will be a magnitude 6.7 or greater earthquake somewhere within the Bay Area within the next 30 years.

The distances to the major active faults from the project site and the estimated probability of a $M_W \geq 6.7$ within 30 years for each fault are listed in the following Table 2. The attached Plate 6, Regional Fault Map, depicts the major active fault locations with respect to the subject site.

**Table 2**
SignificantEarthquakeScenarios

| Fault | Approximate Distance from Site (kilometers)[1] | Location with Respect to Site | Probability of $M_W \geq 6.7$ within 30 Years[2] |
|---|---|---|---|
| San Andreas (Entire) | 1.0 | W | 33% |
| San Andreas (Peninsula) | 1.0 | W | 9% |
| Hayward –Rogers Creek | 29.0 | ENE | 32% |
| Calaveras | 41.3 | ENE | 25% |
| San Gregorio | 12.5 | SW | 5% |

[1]USGS Fault files - Google Earth
[2]Working Group on California Earthquake Probabilities, 2013.

## 7.0 SUBSURFACE CONDITIONS

### 7.1 Soils and Bedrock

Boring B-1, advanced uphill of the mudslide scarp into undisturbed ground, encountered about 5 feet of fill consisting of stiff to very stiff sandy lean clay. The fill, in turn was underlain by Franciscan greenstone decomposed to a stiff sandy clay matrix down to practical refusal depth of about 10 feet below the ground surface.

Borings B-2 and B-3, located within the mudslide mass, revealed approximately 8 feet of mudslide material which consisted of nearly saturated clayey soil which had a soft consistency in the upper few feet and gradually became medium stiff down to its bottom where intensely weathered to decomposed Franciscan greenstone was encountered. The greenstone consisted of a very stiff sandy clay matrix down to the maximum explored depth of 14 feet.

The shallow borings, Borings B-4 and B-5,were advanced into the base of the mudslide scarp and revealed the presence of Franciscan formation decomposed to a moist, very stiff, sandy clay matrix.

Borings B-6 through B-8 were drilled as a part of this supplemental investigation. Boring B-6is located near the eastern boundary of the mudslide and was drilled to 10 feet below ground surface. The soil boring revealed the presence of approximately 7 feet of soft to medium stiff lean clay with sand to sandy lean clay underlain by 2 feet of stiff lean clay (decomposed bedrock) which in-turn was underlain by moderately soft, closely fractured Franciscan formation sandstone.

Boring B-7, located just outside the mudslide area, was drilled to 9 feet bgs. The boring revealed the presence of about 4 feet of fill consisting of aggregate baserock in the top foot and 3 feet of stiff to hard lean clay. The fill material was underlain by about 1.5 feet of native, hard, lean clay with sand which transitioned to intensely weathered, moderately soft, and very closely fractured Franciscan formation greenstone with clay infill.

Boring B-8, located within the access road, revealed the presence of approximately 2 feet of fill-material consisting of very stiff lean clay overlying 4 feet of hard sandy lean clay which was interpreted to be native material. Intensely to moderately weathered, soft, Franciscan formation mélange was encountered approximately 6 feet below the ground surface.

None one of the three soil borings drilled in December, 2017 (B-6, B-7, and B-8) revealed the presence of any serpentinite rock.

### 7.2 Groundwater

Groundwater seepage was noted at a depth of 13½ feet below ground surface (bgs) in borings B-1. However, groundwater was not encountered in any of the other borings drilled for this investigation (Borings B-2 thru B-8). We noted that seepage still persisted from the scarp area upslope from boring B-2, even after nearly one month of dry weather.Seepage was noted to protrude from the native scarp as well as from the trench backfill of the severed sewer main and lateral and the severed storm drain pipe. We note that groundwater levels vary seasonally from inclement weather and that the groundwater level at the site was likely much shallower during the rainy season of 2016/2017. More details on the subsurface soil and groundwater conditions at the site, refer to the attached boring logs and cross sections.

Plate 3shows cross-sections through various locations within the mudslide area. These cross-sections were developed based on an understanding of site geology and the results of our subsurface exploration. Cross-Section C-C' shows the approximate grade of the former access road and subsurface soil conditions along the approximate location of the proposed retaining wall. It is quite evident from this section that the soil conditions are quite variable across the proposed wall.

## 8.0 CONCLUSIONS AND RECOMMENDATIONS

### 8.1 General

It is our opinion thatthe mudslide was caused by deep saturation of the ground by a combination of sustained heavy rainfall in the area, concentrated runoffs from: a nearby concrete V-ditch within the adjacent 1560 Seneca Lane residential property; a nearby damaged storm drain pipe; and seepage of the water collected in the granular backfill of the sewer line. The granular backfill of the sewer line most-likely acted as a conduit for the water collected in the uphill areas. The sewer line backfill was exposed in the more-recent head scarp area of the mudslide. The site area is relatively steep, and was considered to be only marginally stable prior to the saturation of the ground, and it is believed that the mudslide was caused by additional saturation of the ground during the rainstorms.

The resulting head scarp was observed to be approximately 20 feet in height, and nearly 1H:1V in gradient. At the time of our subsurface exploration water was profusely seeping from the head scarp area and the granular backfill of the broken sewer line. Based on the review of the field conditions, it was our opinion that because of the steep slope inclination, overall height of the slope, and ground saturation, future slope failuresare likely. As a temporary mitigation measure, pumps were installed in the west manhole to transport sewage to the east manhole through a flexible hose.

Keeping the goal of maintaining uninterrupted flow of sewage through gravity flow in the affected portion of the line, BAGG evaluated various mitigation solutions including: 1) removal of the loose mudslide material to firm ground and backfilling the exposed area with rip rap; 2) installing drilled piers only to support the sewer line; and 3) installing a soldier pier and lagging wall with possible tiebacks, and engineered backfill as shown in the attached Plate 4.

The rip rap option would include excavation of the mudslide material from the scarp area down to stable material. A toe keyway would be included downslope of the impacted sewer main to initiate the rip rap and additional benches would be added upslope to further anchor the rip rap into stable underlying ground. Prior to placing the rip rap, the slide repair section would be covered with a filter fabric and the rip rap material would consist of 1- to 2-ton angular rocks. The top the rip rap grades would be designed to more or less match the original grade. The sewer line pipe would be designed to be an above-ground pipe, butwould be placed in roughly the same location as the old sewerline.

This option was dropped from consideration because a large volume of slide material would have to be removed to key the rip rap into competent material. Additionally, the transportation and handling of riprap at the site would be very difficult due to access constraints. Clearing of the loose mudslide material prior to placement of riprap would likely involve relatively high, steep cuts that could trigger further temporary slope instability.

The second option would have included installation of a new sewerline at very close to its original location, but on top of piers installed through the mudslide mass and into competent native material. The new sewerline would be connected to the piers and be suspended above ground between the pier supports. This option was dropped from consideration because it would not: 1) stabilize the mudslide area; 2) the piers will have to be designed for significant lateral forces; and 3) the resulting piers would need to be very deep, and relatively large in diameter with massive H-Beams and/or steel reinforcement.

The preferred option would include drilling the soldier piers to the design depths, removal of mudslide material to firm ground in the areas behind the wall, installation of lagging and drainage layer behind the wall and placement of engineered fill behind the wall. The sewerline would be placed at its previous location in the retaining wall backfill area. This option will help minimize the further uphill migration of the mudslide scarp. Portions of the wall may need tiebacks because of the significant height of the retained cut. The backfill portion of the wall should be provided with surface runoff collection and management system to minimize future erosional failures.

However, please note that this option is not without challenges as a temporary access road will be needed to bring a large-sized drilling rig capable of drilling the pier holes, crane for handling and installation of steel I-Beams in the pier holes, concrete trucks for backfilling the holes, and grading equipment for handling and compacting engineered fill behind the wall. This road may later be used by the County's maintenance staff for temporary access to other portions of the sewer line.

Please note that during our geotechnical subsurface exploration, serpentinite was encountered in borings B-1, B-2, B-3, B-4, and B-5. Serpentinite is metamorphic rock that could contain chrysotile, a naturally occurring asbestos (NOA). Environmental profiling for NOA was not in the scope of our services, however, as requested by the County, BAGG tested one sample of the material logged as serpentinite from Boring B-2. The analysis performed followed a standard

California Air Resources Board (CARB) Method 435 preparation and analysis. The test results indicated that asbestos was not detected in the sample.

The scope of our services for the last phase of investigation included collection and testing of additional serpentinite samples to determine the presence of asbestos. Serpentinite was not encountered in any of the three borings (B-6, B-7, and B-8) drilled during the last phase of site investigation to the maximum depths of the borings. Thus, we did not perform any additional asbestos related testing.

Recommendations for the soldier pile and retaining wall, tie-backs and associated earthwork are presented below.

### 8.2 Soldier Pile and Tie Back Retaining Wall

The actual design of the retaining wall piers will be determined by the project Structural Engineer. However, we envision a soldier pier and retaining wall with a retained height of up to 15 feet, supported with 20-foot-deep drilled piers and tie-backs extending approximately 30 feet into the hillside. The top of the drilled piers (bottom of the retaining wall)should coincide with the top of the firm rock (6 feet in B-7, 8 feet in Boring B-2, near surface in Boring B-5, 8 feet in B-3, and 8 feet in B-6). The top of firm rock depth should be confirmed by our office during construction of the wall. Below this depth, the piers can obtain passive resistance from the undisturbed native bedrock formation. The approximate layout of the retaining wall is shown on the attached Plate 2, Site Plan. The retaining wall should be designed in accordance with the wall pressures shown on Plate 20. The soil pressures behind the retaining wall may be resisted by passive pressure acting over 2 times the diameter of the soldier piers. For design purposes, the passive pressure may be assumed to be 500 pcf, equivalent fluid weight. Because of the sloping ground in front of the piers and the likely hood of the rock dipping down at a steep angle, the passive pressure from the top 3 pier diameters should be ignored. The wall should be designed to withstand seismic pressures taken as uniform distribution of 5H pounds per square foot. The designer of the soldier pile should include appropriate vehicular surcharge loads in the design of the retaining wall.

To prevent hydrostatic pressure build-up behind the soldier pile retaining wall, a minimum 1-foot wide drainage blanket should be installed behind the retaining wall, extending from the top of the wall to the bottom of the wall. The drainage material should consist of Caltrans Class 2 permeable material or crushed drain rock surrounded by a suitable filter fabric, and should drain via 3-inch diameter weep holes, or 4-inch diameter perforated pipe installed near the bottom of the retaining wall. Alternatively, wall drainage may be provided by geocomposite drainage layer extending to one foot below the top of the wall backfill. The top one foot of wall backfill should consist of clayey backfill. Spacers should be provided between the wall lagging to allow for removal of water from the backfill area.

If tie backs are used to support the wall, the bonded portion of the tiebacks should extend beyond the imaginary plane extended upward from the base of the wall at an angle of 30 degrees between the wall and the plane. Tiebacks should be stress tested to: 1) demonstrate that anchors meet the acceptance criteria and 2) lock-off the tendons at specified load. Tieback testing should be performed in accordance with the procedures outlined in Trenching and Shoring Manual by State of California, Department of Transportation, dated August 2011. Based on tie-back factored loads provided by the project structural engineer we do not anticipate the tie-backs will encroach the existing soldier pile retaining wall upslope from the site.

### 8.3 Excavation and Backfill

To address the more recent mudslide that receded upslope and encroached the residential property upslope, the soils behind the retaining wall should be excavated and replaced with engineered fill benched into competent material, as determined by the Geotechnical Engineer (BAGG Engineers). Subdrains consisting of a minimum 2-foot wide by 4-foot high envelope of

Class 2 permeable material with a minimum 6-inch diameter perforated PVC pipe (holes facing down) placed within the bottom portion of the permeable material should be constructed at the rear of the keyway at 10-foot vertical intervals or as determined in the field by the Geotechnical Engineer. Subdrains should drain via gravity flowinto solid pipes extending through the retaining wall, if necessary, and into flexible pipes (without perforations) anchored into firm ground. Energy dissipaters should also be provided at the outlet locations for the retaining wall and keyway subdrains.On-site soils may be utilized for fill material provided they are free of organics and rock fragments greater than 2-inch size. On-site soils should be compacted to not less than 90% relative compaction, while above optimum moisture content as determined by ASTM D1557.

We note that the severed storm drain line should be repaired and re-routed such that it discharges onto an energy dissipater located off the mudslide area. BAGG will review the project plans and provide as needed consultation services to the design engineer to develop options for rerouting the severed storm drain line and other sources which could contribute to concentrated surface runoff in the backfill area.

### 8.4 Winterization

We understand the sewerline repair will not take place until Summer 2018, therefore, winterization measures will need to be implemented to help minimize further migration of the mudslide. Temporary mitigation measures have consisted of keeping the sewer alignment functional via pump system, conveying runoff from the upslope neighboring concrete lined v-ditch away from the mudslide area, and also installing visqueen on the sloping ground upslope of the concrete-lined v-ditch. As a minimum, winterization measures should consist of maintaining these recently installed temporary mitigation measures, in addition to the following.

The upper portion of the slide area should be covered with visqueen to minimize surface water infiltration into the underlying mudslide debris. The visqueen shouldextend a minimum of 15 feet upslope from the scarp. Above the scarp of $Qls_2$ the visqueen may terminate at the concrete-lined v-ditch provided the existing visqueen above the v-ditch is maintained. Below the scarp, the visqueen should extend a minimum of 30 feet downslope of the scarp for $Qls_1$ and at least 60 feet downslope of the scarp for $Qls_2$. The visqueen should be extended at least 15 feet beyond the east and west limits of the mudslide.

Runoff from the visqueen covered areas should be managed to minimize erosion of uncovered areas. The runoff from the visqueen should be diverted to suitable discharge area(s). The project civil engineer should coordinate with BAGG Engineers to establish appropriate discharge areas. BAGG Engineers should be allowed to review the final winterization plan prepared by the project civil engineer.

The damaged corrugated metal stormdrain pipe protruding from the west side of the mudslide still appeared to be producing water during our field exploration. Efforts should be made to investigate the origin of this runoff and divert it away from the mudslide area. As a minimum, a temporary flexible pipe should be connected to the severed storm drain pipe to divert any runoff away from the slide area and to the natural swale west of the slide area. Additionally, the severed storm drain pipe consists of corrugated metal and may be corroded and in need of replacement.

### 8.5 Plan Review

It is recommended that the Geotechnical Engineer (BAGG Engineers) be retained to review the winterization, foundation, drainage, and final grading plans. This review is to assess general suitability of the earthwork, foundation, and drainage recommendations contained in this report and to verify the appropriate implementation of our recommendations into the project plans and specifications.

### 8.6 Observation and Testing

It is recommended that the Geotechnical Engineer (BAGG) be retained to provide observation and testing services during site grading, excavation, backfilling, and foundation construction phases of work. This is intended to verify that the work in the field is per our recommendations and in accordance with the approved plans and specifications, and more importantly verify that subsurface conditions encountered during construction are similar to those anticipated during the design phase. Unanticipated soil conditions may warrant revised recommendations. Therefore, BAGG cannot accept responsibility for the recommendations contained in this report if we are not retained to provide observation and testing services during construction.

## 9.0 CLOSURE

This report has been prepared in accordance with generally-accepted engineering practices for the strict use of BKF Engineers, and other professionals associated with the specific project described in this report. The recommendations presented in this report are based on our understanding of the proposed project as described herein, and upon the soil conditions encountered in eight widely spaced borings advanced for this investigation. The recommendations contained in this report are intended to stabilize the sewer line and roadway, butgive no warrantee regarding future stability of the existing fill slope above the repair or the undisturbed slide mass below the recommended repair.

The conclusions and recommendations contained in this report are based on subsurface conditions revealed by widely spaced borings, limited laboratory test data,and on a review of available geotechnical and geologic literature pertaining to the project vicinity. It is not uncommon for unanticipated conditions to be encountered during site grading and/or foundation excavations and it is not possible for all such variations to be found by a field exploration program appropriate for this type of project. The recommendations contained in this report are therefore contingent upon the review of the final grading, drainage, and foundation plans by this office, and upon geotechnical observation and testing by BAGG of all pertinent aspects of site grading, including placement of fills and backfills, and foundation construction.

Subsurface conditions and standards of practice change with time. Therefore, we should be consulted to update this report, if grading and construction does not commence within 6 months from the date this report is submitted or next winter. Additionally, the recommendations of this report are only valid for the proposed development as described herein. If the proposed project is modified, our recommendations should be reviewed and approved or modified by this office in writing.

Attachments:

| | |
|---|---|
| Plate 1 | Vicinity Map |
| Plate 2 | SitePlan |
| Plate 3 | Cross Sections A-A' thru E-E' |
| Plate 4 | Remedial Cross Sections A-A' thru E-E' |
| Plate 5 | Regional Geologic Map |
| Plate 6 | Regional Fault Map |
| Plate 7 | Unified Soil Classification System |
| Plate 8 | Soil Terminology |
| Plate 9 | Rock Terminology |
| Plate 10 | Boring Log Notes |
| Plate 11 | Key to Symbols |
| Plates12 through 19 | Logs of Borings B-1 thru B-8 |
| Plate 20 | Representative Earth Pressure Diagram |

ASFE document titled "Important Information About Your Geotechnical Engineering Report"

## 10.0 REFERENCES

Association of Bay Area Governments (ABAG), 2003, *Modeled Shaking Intensity Maps.*

Brabb, E. E., Graymer, R.W. Jones, D.L., 1998, Geology of the Palo Alto 30 X 60 Minute Quadrangle, California: a digital database, U.S. Geological Survey Open File Report 98-348.

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Computer slope stability program PCSTABL developed by Purdue University in 1988 and improved with a smart editor developed by Harald Van Aller 1996.

E.E. Brabb, R.W. Graymer, and D.L. Jones, 2000, Geologic Map and Map Database for the Palo Alto 30'x60' Quadrangle, California, Miscellaneous Field Studies Map MF-2332, U.S.G.S.

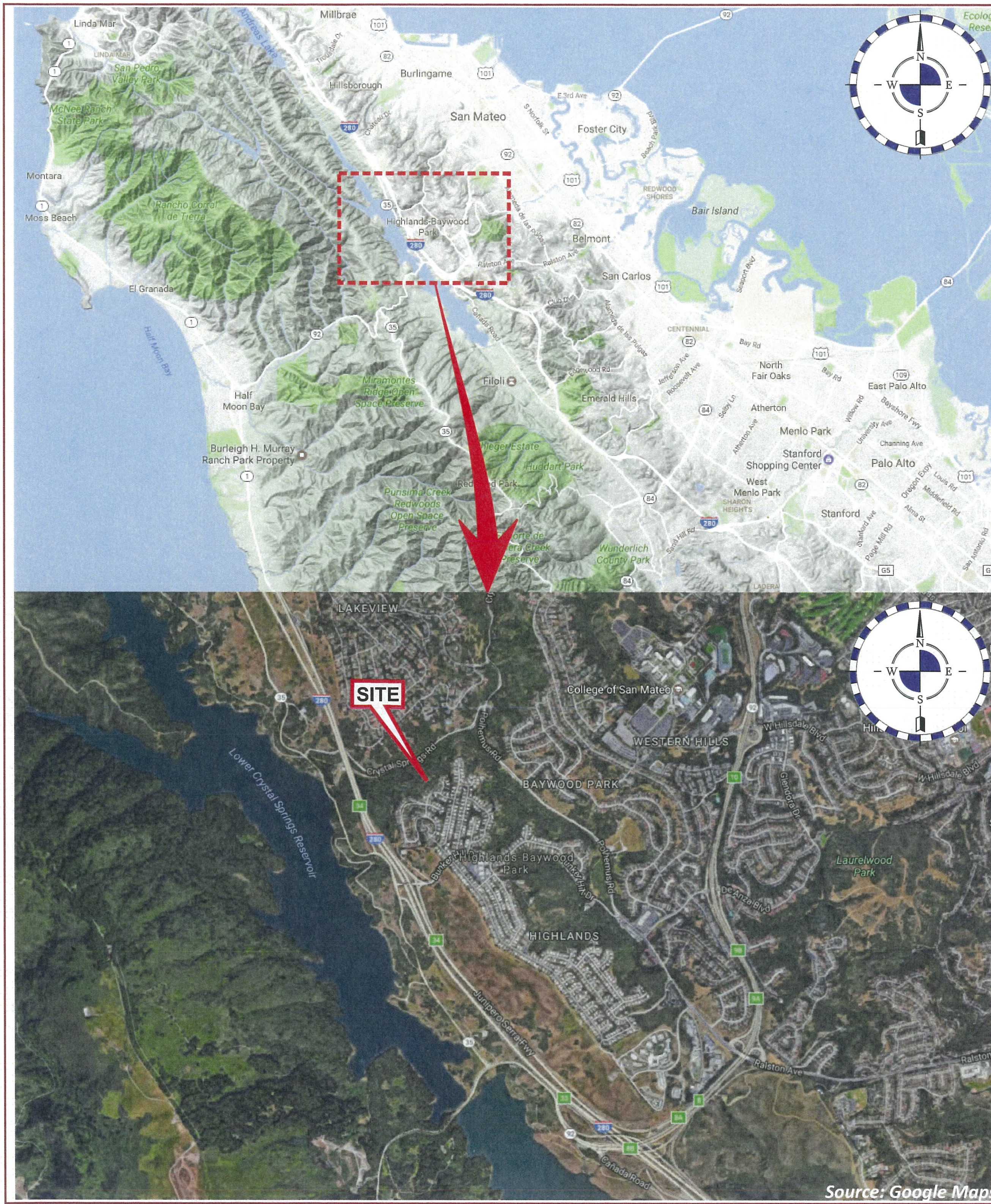
Keefer, D.K., 1984, Landslides caused by earthquakes: Geological Society of America Bulletin, v. 95, no. 4, p. 406-421.

E.H. Pampeyan, 1994, Geologic Map of the Montara Mountain and San Mateo 7-1/2' Quadrangles, San Mateo County California, U.S. Geological Survey Miscellaneous Investigations Series Map I-2390.

*Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Landslide Hazards in California*, Southern California Earthquake Center, June 2002.

Working Group on Northern California Earthquake Potential, *Database of Potential sources for Earthquake Larger Than Magnitude 6 in Northern California*, Open-File Report 96-705, U.S. Geological Survey, 1996.

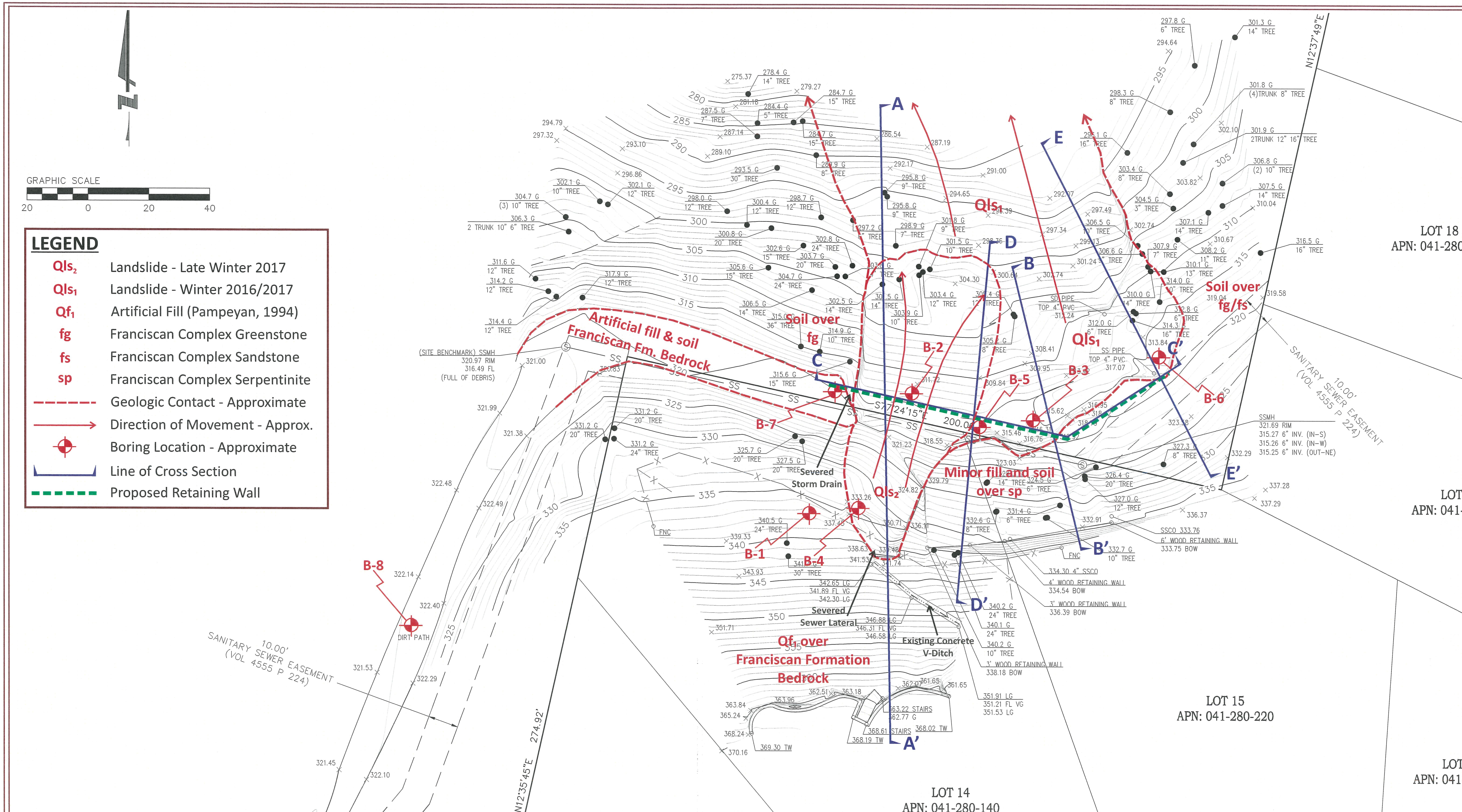
Working Group on California Earthquake Probabilities, 2008, *The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF2)*, U. S. Geological Survey Open File Report 2007-1437.




SUPPLEMENTAL GEOTECHNICAL ENGINEERING INVESTIGATION
SENECA LANE MUDSLIDE
SEWER STABILIZATION PROJECT
SAN MATEO COUNTY, CALIFORNIA

**VICINITY MAP**

| DATE: | JOB NUMBER: | PLATE |
|---|---|---|
| January 2018 | BKFEN-34-00 | 1 |




Base: "1560 Seneca Lane Partial Topographic Survey, San Mateo County, California," Topo 1 of 2, Prepared by BKF Engineers, Job No. 20150221-15, dated 1/10/18.

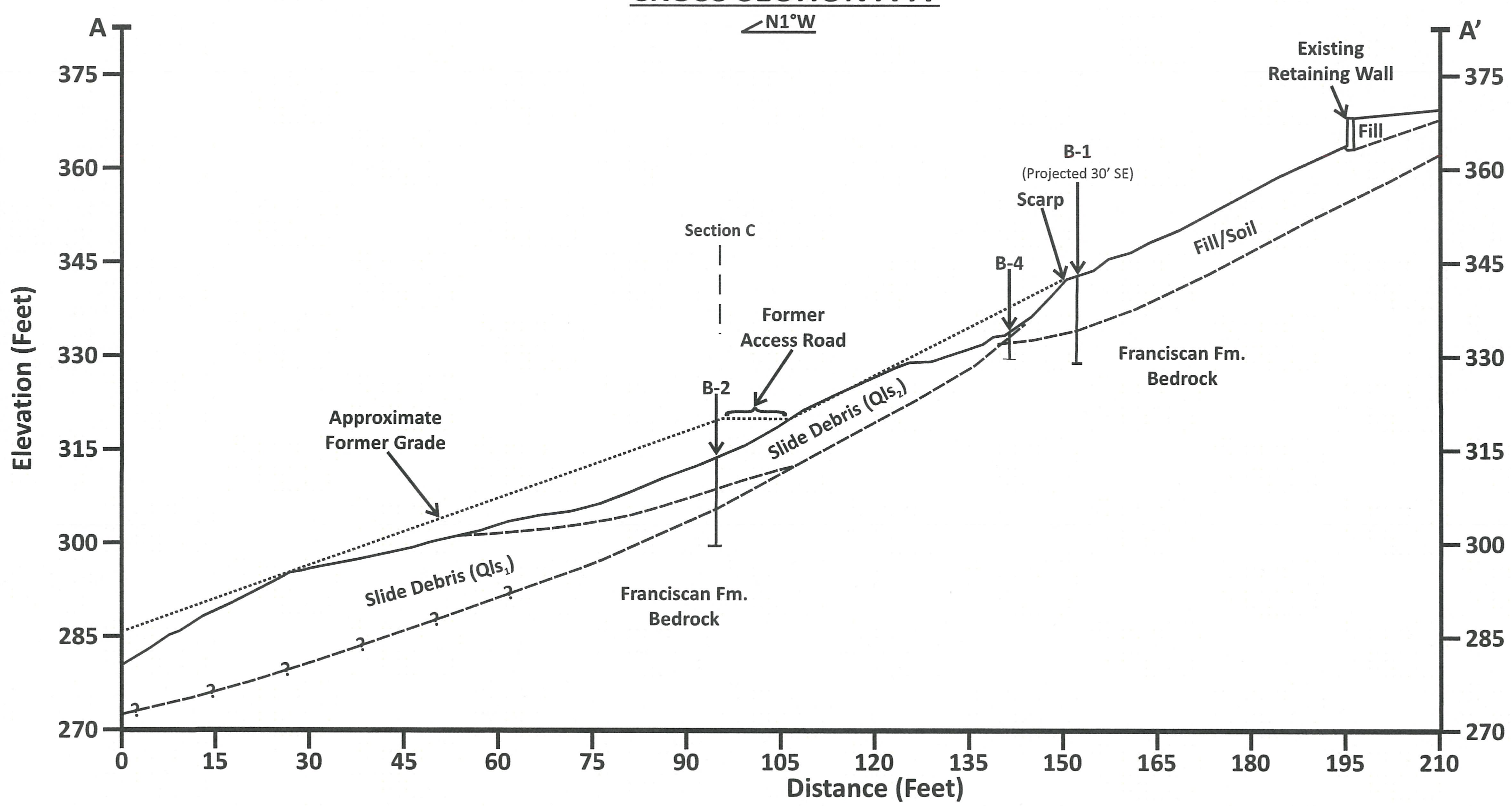
**SUPPLEMENTAL GEOTECHNICAL ENGINEERING INVESTIGATION**
**SENECA LANE MUDSLIDE**
**SEWER STABILIZATION STUDY**
**SAN MATEO COUNTY, CALIFORNIA**

BAGG ENGINEERS

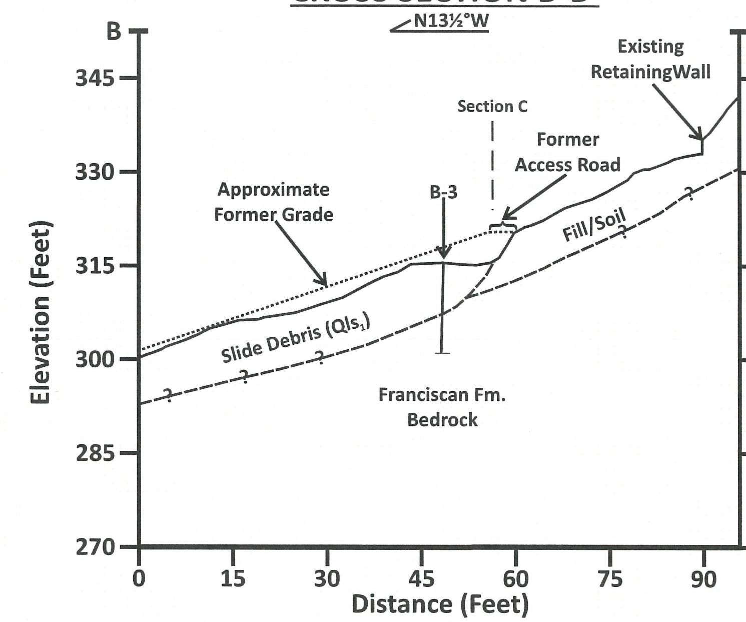
**SITE PLAN**

| JOB NO. | SCALE: | DATE | PLATE |
|---|---|---|---|
| BKFEN-34-00 | 1" ≈ 30' | January 2018 | 2 |

## CROSS SECTION A-A'



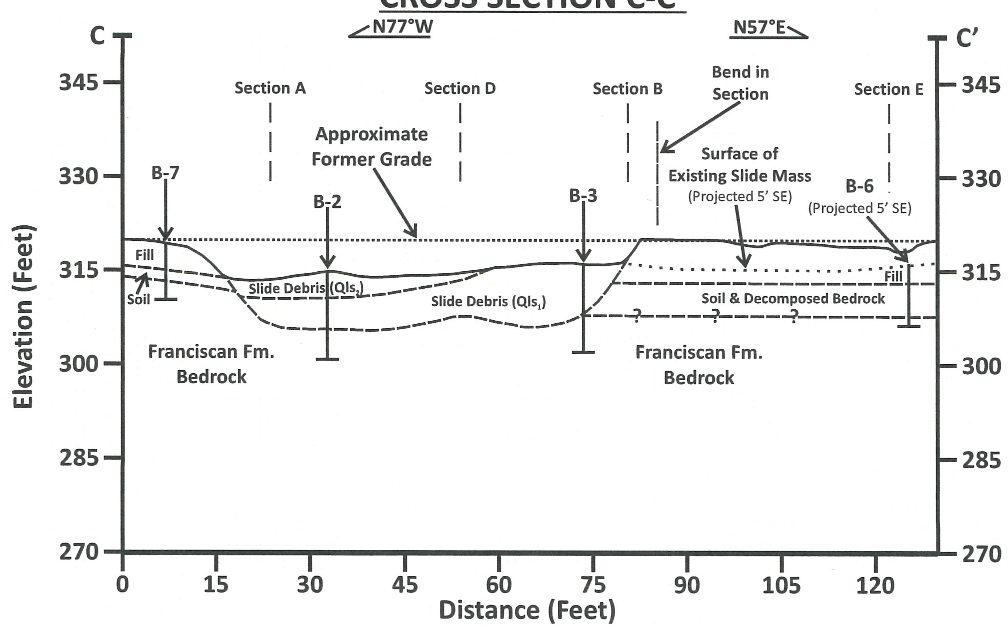

## CROSS SECTION B-B'



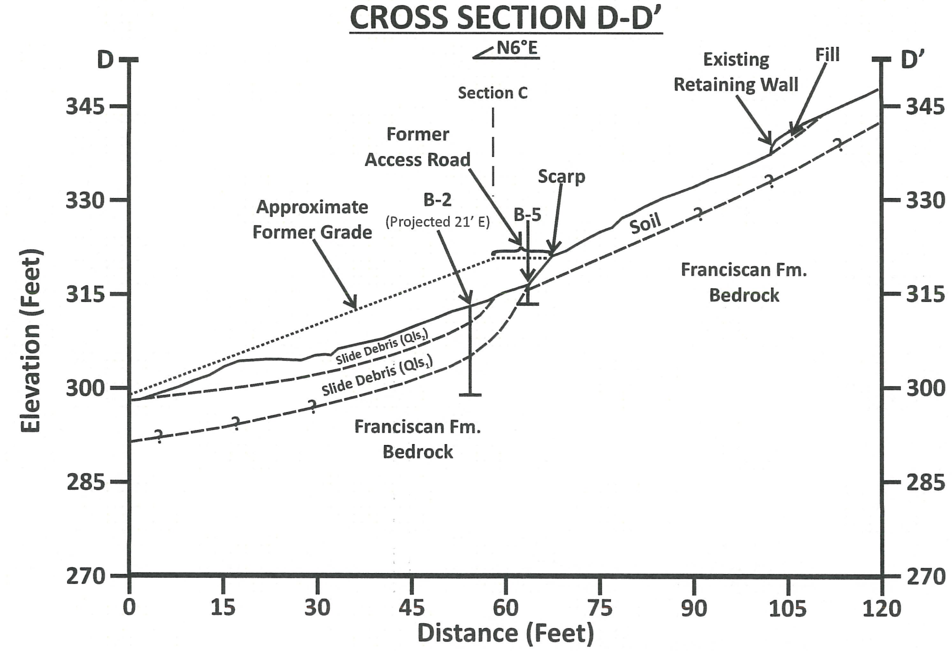

### Legend

- Existing Grade
- Geologic Contact - Approximate
- Geologic Contact - Inferred
- Former Existing Grade - Inferred
- B-1 Boring Location - Approximate

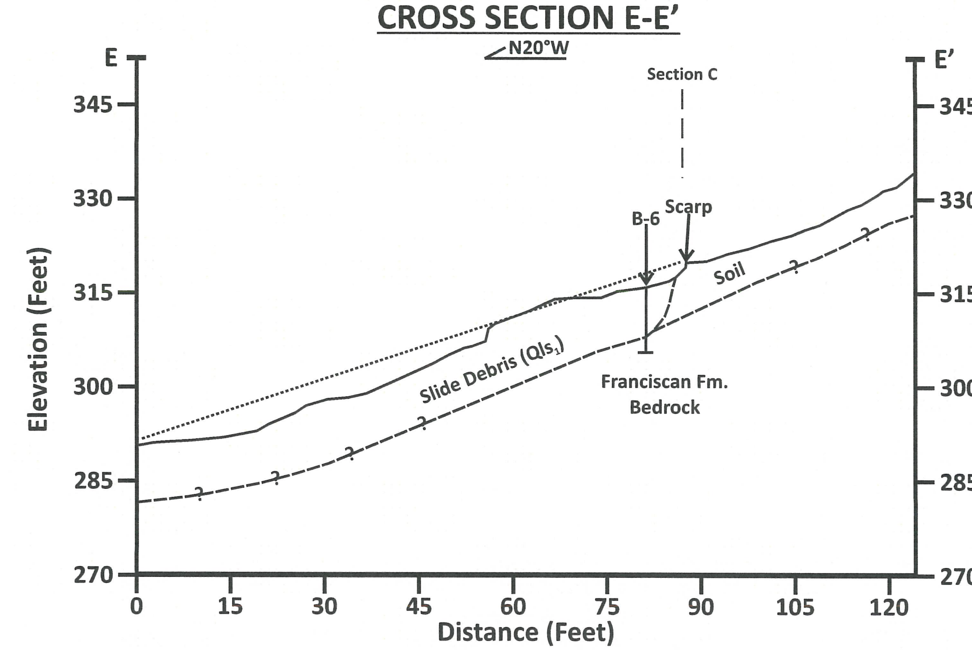
## CROSS SECTION C-C'




## CROSS SECTION D-D'




## CROSS SECTION E-E'




**Note:** Elevations based on "1560 Seneca Lane Partial Topographic Survey, San Mateo County, California," Topo 1 of 2, Prepared by BKF Engineers, Job No. 20150221-15, dated 1/10/18.

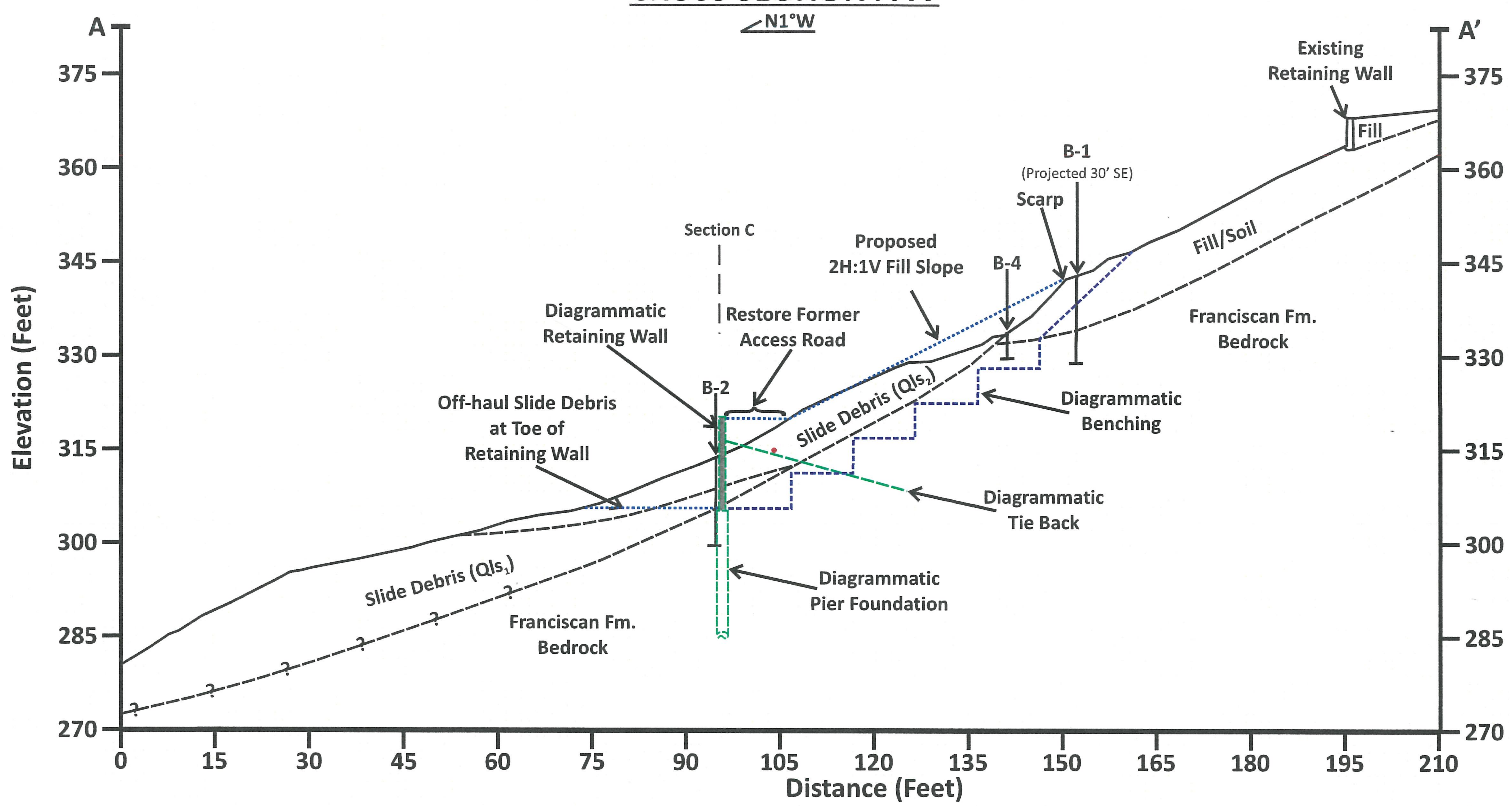
SUPPLEMENTAL GEOTECHNICAL ENGINEERING INVESTIGATION
SENECA LANE MUDSLIDE
SEWER STABILIZATION PROJECT
SAN MATEO COUNTY, CALIFORNIA

BAGG ENGINEERS

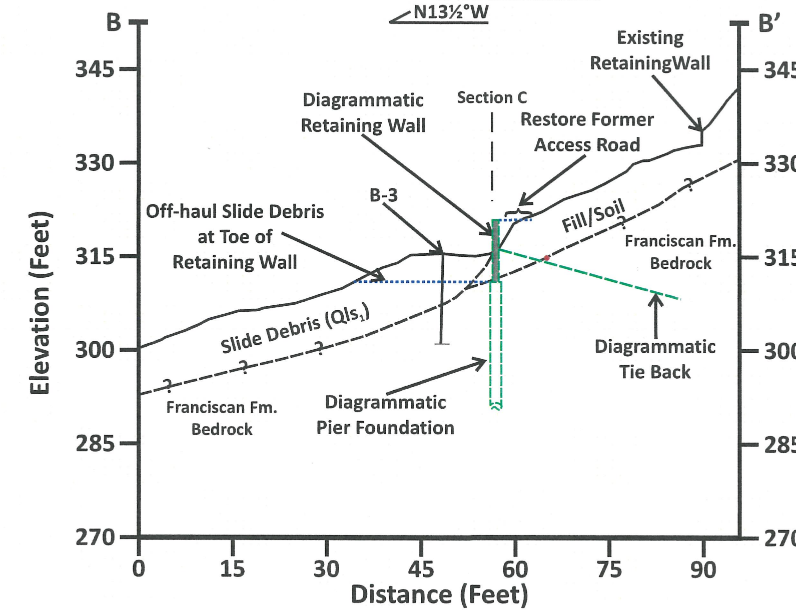
CROSS SECTIONS A-A' THRU E-E'

| JOB NUMBER: | SCALE: | DATE: | PLATE |
|---|---|---|---|
| BKFEN-34-00 | 1" ≈ 30' | January 2018 | 3 |

## CROSS SECTION A-A'




## CROSS SECTION B-B'

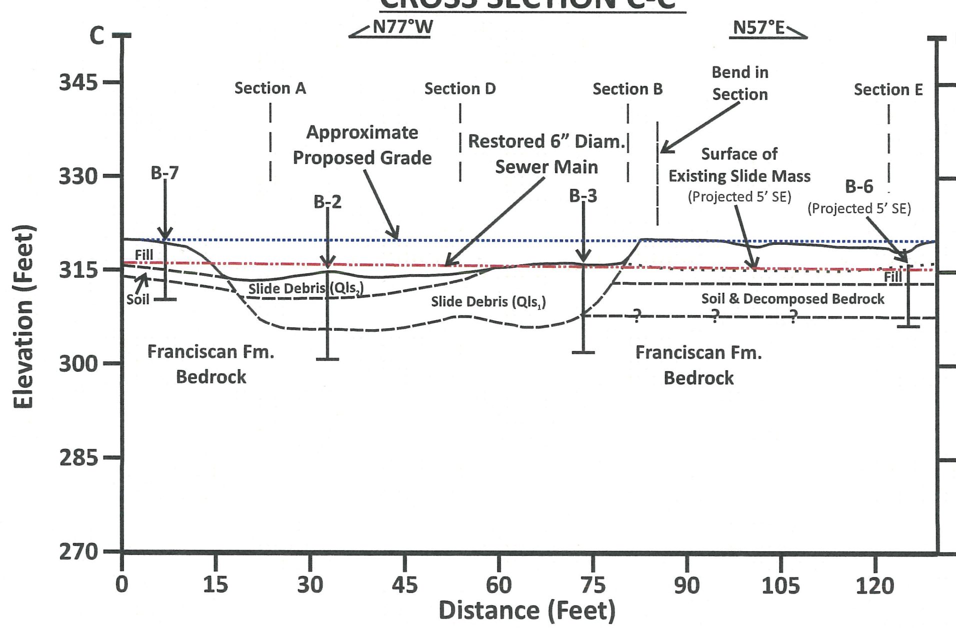



### Legend

- Existing Grade
- Geologic Contact - Approximate
- Geologic Contact - Inferred
- Former Existing Grade - Inferred
- B-1 Boring Location - Approximate
- Proposed Structures
- Proposed Grade
- Diagrammatic Grading
- Existing/Restored Sewer Main

* Retaining Wall Drainage and Site Grading Per Soils Report

## CROSS SECTION C-C'

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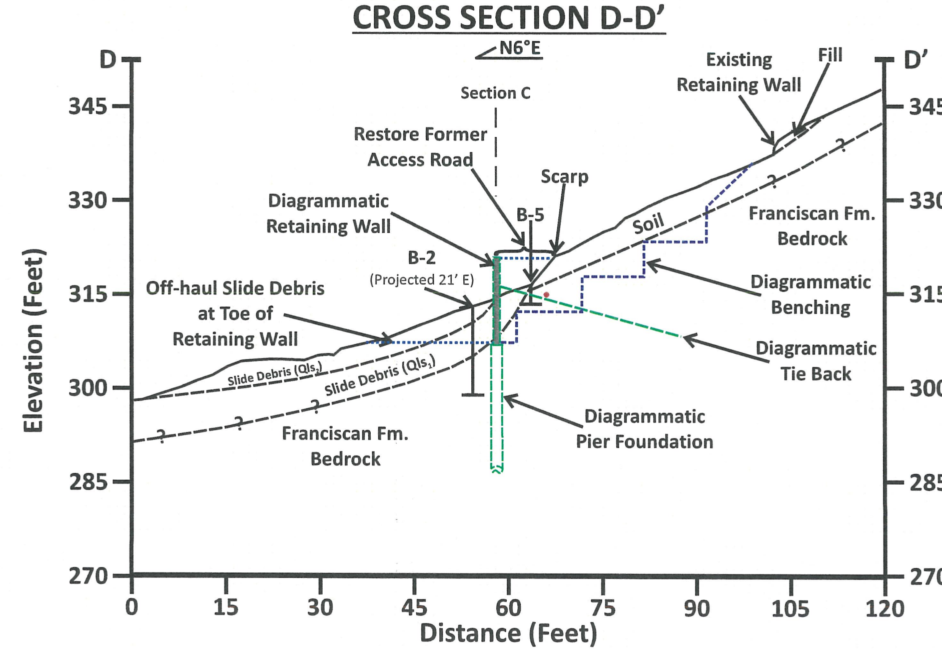


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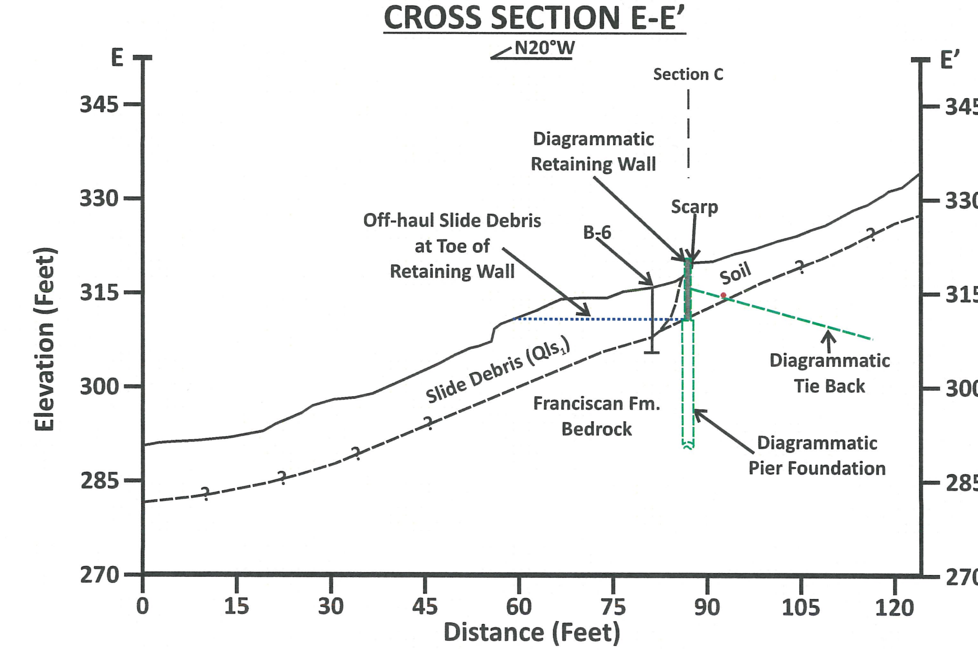


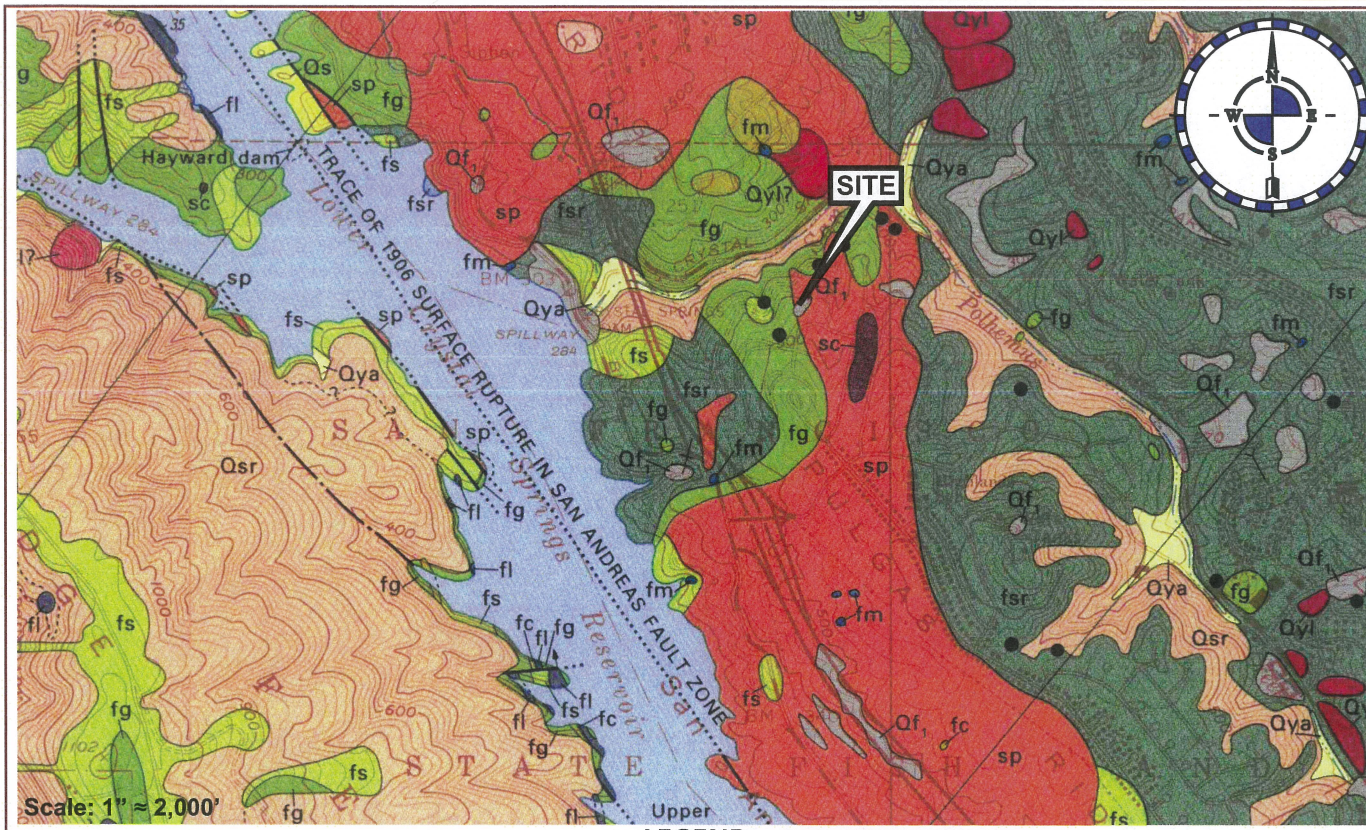

**Note:** Elevations based on "1560 Seneca Lane Partial Topographic Survey, San Mateo County, California," Topo 1 of 2, Prepared by BKF Engineers, Job No. 20150221-15, dated 1/10/18.

SUPPLEMENTAL GEOTECHNICAL ENGINEERING INVESTIGATION
SENECA LANE MUDSLIDE
SEWER STABILIZATION PROJECT
SAN MATEO COUNTY, CALIFORNIA

BAGG ENGINEERS

REMEDIAL CROSS SECTIONS A-A' THRU E-E'

| JOB NUMBER: | SCALE: | DATE: | PLATE |
|---|---|---|---|
| BKFEN-34-00 | 1" ≈ 30' | January 2018 | 4 |




## LEGEND

**Qya Younger alluvium** (Holocene): Unconsolidated and undissected, poorly sorted gravel, sand, silt, clay, and organic matter in active modern drainage channels and small fans. Grades into fine- to coarse-grained alluvial deposits. Locally interfingers with or includes slope wash, ravine fill, and colluvium. In many places included with other alluvial deposits because of map scale limitations.

**Qsr Slope wash, ravine fill, and colluvium** (Holocene): Unconsolidated to moderately consolidated deposits of sand, silt, clay, and rock fragments accumulated by slow downslope movement of weathered rock debris and soil. Composition dependent upon underlying rocks. Commonly unsorted and unbedded, but locally crudely layered by downslope movements. Mapped where thickness presumed to exceed 5 ft; as thick as 20 ft on north side of San Pedro Valley. Maximum accumulations commonly develop near bases of slopes underlain by sheared rock (fsr) of the Franciscan Complex. Deposists interfinger with alluvial deposits at base of slopes. Locally includes alluvial deposits and older landslide deposits (Qol) too small to show at this scale.

**$Qf_1$ Artificial fill - Unit 1** (Holocene): Poorly consolidated to well-consolidated gravel, sand, silt, and rock fragments in various combinations used in a variety of applications including riprap, highway-, railroad-, and airport runway-fills, earthfill dams, reservoir embankments, and building site grades. Thickness and consolidation dependent upon type of application and site. Includes organic and man-made debris in sanitary landfills and spoil from tunneling operations. Many small fills not shown because of map-scale limitations.

**fs Franciscan Complex Sandstone** (Cretaceous and Jurassic): Medium- to coarse-grained, poorly sorted, locally tuffaceous sandstone (lithic graywacke) with interbedded siltstone, shale, and sparse coal. Well indurated, hard, and dark greenish-gray when fresh; weakly indurated, soft, and grayish-orange when weathered. Most natural exposures are deeply weathered, but locally graywacke forms bold outcrops owing to a higher degree of induration or cementation. West of the San Andreas Fault most graywacke occurs in a crudely layered sequence with Franciscan greenstone; east of San Andreas Fault graywacke typically occurs as tectonic inclusions in a matrix or sheared rock (fsr) but also is interlayered with chert (fc). As mapped, unit may locally include sheared rock (fsr).

**fg Franciscan Complex Greenstone** (Cretaceous and Jurassic): Dark green to red, altered basaltic volcanic rocks, including flows, pillow lava, breccia, tuff, and minor related intrusive rock. Friable to hard and dense depending upon rock type and degree of weathering. West of the San Andreas Fault most greenstone occurs in discrete lenticular units interlayered with Franciscan sandstone (fs); east of the San Andreas Fault greenstone occurs mainly as rounded tectonic inclusions in a matrix of sheared rock (fsr).

**fsr Sheared rock** (Cretaceous and Jurassic): Predominantly soft, light- to dark-gray, sheared shale, siltstone, and graywacke containing various-size tectonic inclusions of Franciscan rock types. Weathers to grayish-yellow clayey and silty sand and in places is eroded to form badlands topography. Area of outcrop may be greater than shown and may include some areas labeled as sandstone (fs). Slopes underlain by sheared rock unit are unstable, especially when wet. Thickness unknown but more than several hundreds of feet. Commonly referred to as mélange in the California Coast Ranges.

**sp Serpentinite** (Cretaceous and Jurassic): Soft sheared serpentinite enclosing blocks of hard gray to greenish-gray unsheared serpentinite and ultramafic rocks. West of San Andreas Fault occurs as near vertical tabular bodies in or along faults or shear zones; east of San Andreas Fault occurs largely as flat-lying sheets overlying other Franciscan rocks and as small, near vertical tabular bodies.

***Reference:*** *Geologic Map of the Montara Mountain and San Mateo 7-1/2' Quadrangles, San Mateo County, California*: U.S. Geological Survey Miscellaneous Investigations Series Map I-2390, by E.H. Pampeyan, 1994.

| SUPPLEMENTAL GEOTECHNICAL ENGINEERING INVESTIGATION<br>SENECA LANE MUDSLIDE<br>SEWER STABILIZATION STUDY<br>SAN MATEO COUNTY, CALIFORNIA | REGIONAL GEOLOGIC MAP | | |
|---|---|---|---|
| | DATE:<br>January 2018 | JOB NUMBER:<br>BKFEN-34-00 | PLATE<br>5 |

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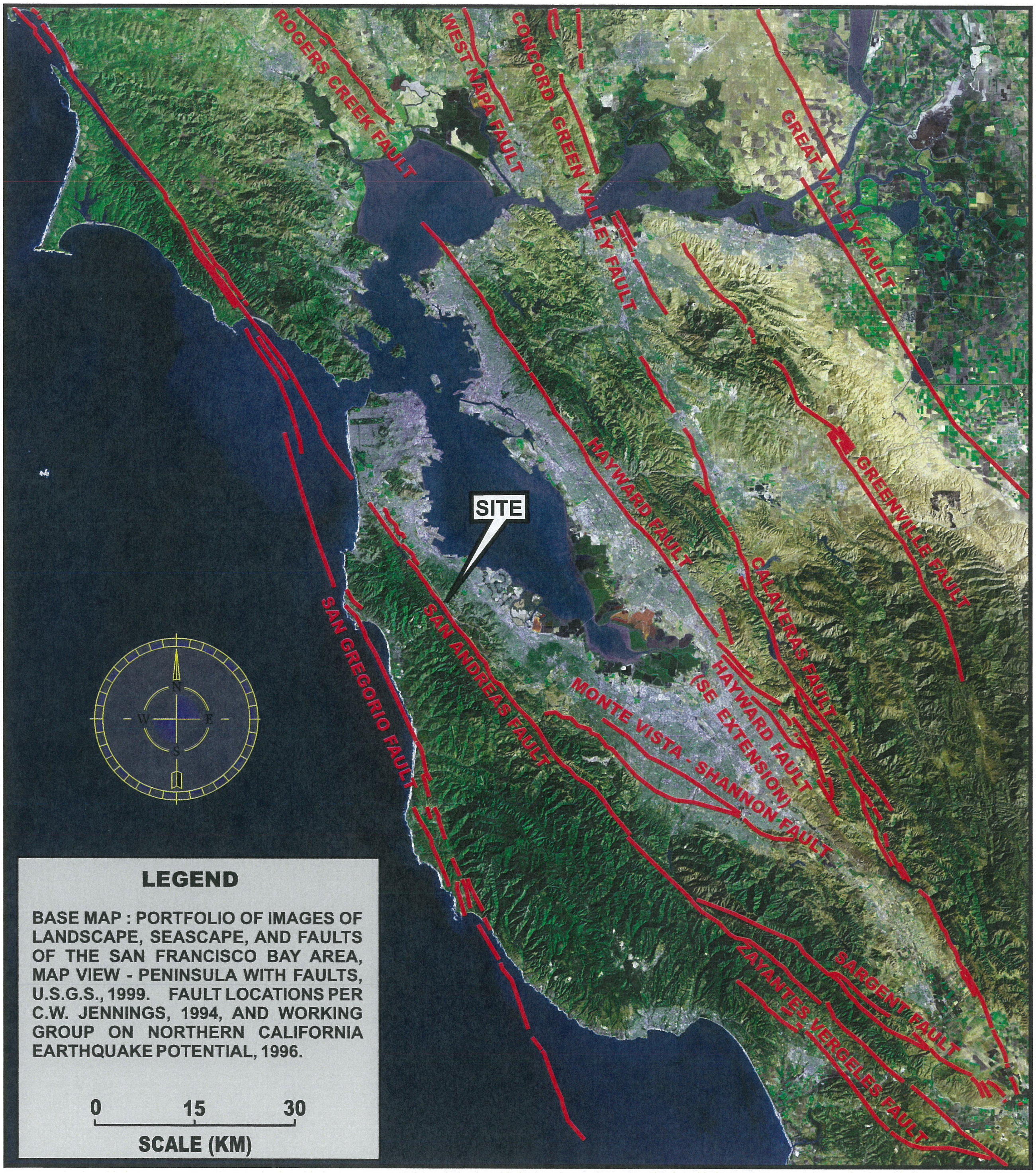



| SUPPLEMENTAL GEOTECHNICAL ENGINEERING INVESTIGATION<br>SENECA LANE MUDSLIDE<br>SEWER STABILIZATION PROJECT<br>SAN MATEO COUNTY, CALIFORNIA | REGIONAL FAULT MAP | | |
|---|---|---|---|
| | DATE:<br>January 2018 | JOB NUMBER:<br>BKFEN-34-00 | PLATE<br>6 |

BAGG ENGINEERS

## COARSE-GRAINED SOILS

LESS THAN 50% FINES*

| GROUP SYMBOLS | ILLUSTRATIVE GROUP NAMES | MAJOR DIVISIONS |
|---|---|---|
| GW | Well graded gravel<br>Well graded gravel with sand | **GRAVELS** More than half of coarse fraction is larger than No. 4 sieve size |
| GP | Poorly graded gravel<br>Poorly graded gravel with sand | |
| GM | Silty gravel<br>Silty gravel with sand | |
| GC | Clayey gravel<br>Clayey gravel with sand | |
| SW | Well graded sand<br>Well graded sand with gravel | **SANDS** More than half of coarse fraction is smaller than No. 4 sieve size |
| SP | Poorly graded sand<br>Poorly graded sand with gravel | |
| SM | Silty sand<br>Silty sand with gravel | |
| SC | Clayey sand<br>Clayey sand with gravel | |

NOTE: Coarse-grained soils receive dual symbols if:
(1) their fines are CL-ML (e.g. SC-SM or GC-GM) or
(2) they contain 5-12% fines (e.g. SW-SM, GP-GC, etc.)

## FINE-GRAINED SOILS

MORE THAN 50% FINES*

| GROUP SYMBOLS | ILLUSTRATIVE GROUP NAMES | MAJOR DIVISIONS |
|---|---|---|
| CL | Lean clay<br>Sandy lean clay with gravel | **SILTS AND CLAYS** liquid limit less than 50 |
| ML | Silt<br>Sandy silt with gravel | |
| OL | Organic clay<br>Sandy organic clay with gravel | |
| CH | Fat clay<br>Sandy fat clay with gravel | **SILTS AND CLAYS** liquid limit more than 50 |
| MH | Elastic silt<br>Sandy elastic silt with gravel | |
| OH | Organic clay<br>Sandy organic clay with gravel | |
| PT | Peat<br>Highly organic silt | **HIGHLY ORGANIC SOIL** |

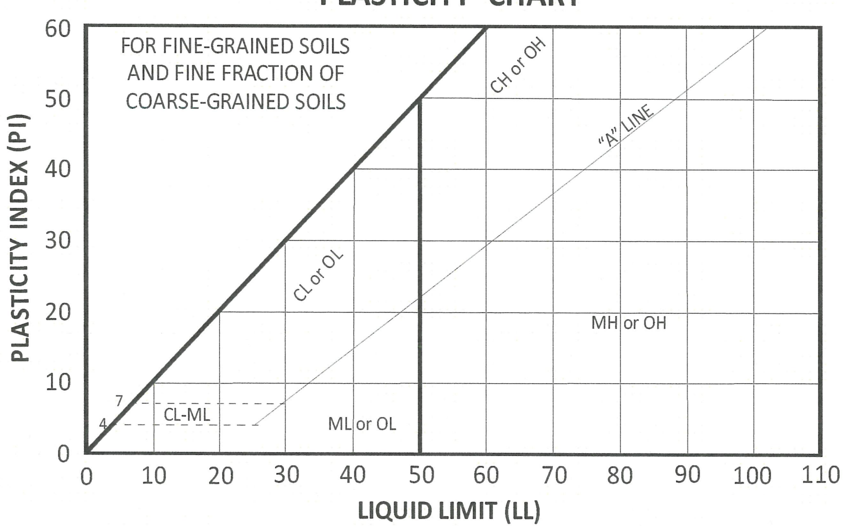
NOTE: Fine-grained soils receive dual symbols if their limits in the hatched zone on the Plasticity Chart(L-M)

## SOIL SIZES

| COMPONENT | SIZE RANGE |
|---|---|
| BOULDERS | ABOVE 12 in. |
| COBBLES | 3 in. to 12 in. |
| GRAVEL | No. 4 to 3 in. |
| Coarse | ¾ in to 3 in. |
| Fine | No. 4 to ¾ in. |
| SAND | No. 200 to No.4 |
| Coarse | No. 10 to No. 4 |
| Medium | No. 40 to No. 10 |
| Fine | No. 200 to No. 40 |
| *FINES: | BELOW No. 200 |

NOTE: Classification is based on the portion of a sample that passes the 3-inch sieve.

## PLASTICITY CHART




Reference: ASTM D 2487-06, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

**GENERAL NOTES:** The tables list 30 out of a possible 110 Group Names, all of which are assigned to unique proportions of constituent soils. Flow charts in ASTM D 2487-06 aid assignment of the Group Names. Some general rules for fine grained soils are: less than 15% sand or gravel is not mentioned; 15% to 25% sand or gravel is termed "with sand" or "with gravel", and 30% to 49% sand or gravel is termed "sandy" or "gravelly". Some general rules for coarse-grained soils are: uniformly-graded or gap-graded soils are "Poorly" graded (SP or GP); 15% or more sand or gravel is termed "with sand" or "with gravel", 15% to 25% clay and silt is termed clayey and silty and any cobbles or boulders are termed "with cobbles" or "with boulders".

# UNIFIED SOIL CLASSIFICATION SYSTEM

BVGG ENGINEERS

**SOIL TYPES (Ref 1)**

**Boulders:** particles of rock that will not pass a 12-inch screen.
**Cobbles:** particles of rock that will pass a 12-inch screen, but not a 3-inch sieve.
**Gravel:** particles of rock that will pass a 3-inch sieve, but not a #4 sieve.
**Sand:** particles of rock that will pass a #4 sieve, but not a #200 sieve.
**Silt:** soil that will pass a #200 sieve, that is non-plastic or very slightly plastic, and that exhibits little or no strength when dry.
**Clay:** soil that will pass a #200 sieve, that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when dry.

**MOISTURE AND DENSITY**

**Moisture Condition:** an observational term; dry, moist, wet, or saturated.
**Moisture Content:** the weight of water in a sample divided by the weight of dry soil in the soil sample, expressed as a percentage.
**Dry Density:** the pounds of dry soil in a cubic foot of soil.

**DESCRIPTORS OF CONSISTENCY (Ref 3)**

**Liquid Limit:** the water content at which a soil that will pass a #40 sieve is on the boundary between exhibiting liquid and plastic characteristics. The consistency feels like soft butter.
**Plastic Limit:** the water content at which a soil that will pass a #40 sieve is on the boundary between exhibiting plastic and semi-solid characteristics. The consistency feels like stiff putty.
**Plasticity Index:** the difference between the liquid limit and the plastic limit, i.e. the range in water contents over which the soil is in a plastic state.

**MEASURES OF CONSISTENCY OF COHESIVE SOILS (CLAYS) (Ref's 2 & 3)**

| | | | |
|---|---|---|---|
| **Very Soft** | N=0-1* | C=0-250 psf | Squeezes between fingers |
| **Soft** | N=2-4 | C=250-500 psf | Easily molded by finger pressure |
| **Medium Stiff** | N=5-8 | C=500-1000 psf | Molded by strong finger pressure |
| **Stiff** | N=9-15 | C=1000-2000 psf | Dented by strong finger pressure |
| **Very stiff** | N=16-30 | C=2000-4000 psf | Dented slightly by finger pressure |
| **Hard** | N>30 | C>4000 psf | Dented slightly by a pencil point |

*__N__=blows per foot in the Standard Penetration Test. In cohesive soils, with the 3-inch-diameter ring sampler, 140-pound weight, divide the blow count by 1.2 to get N (Ref 4).

**MEASURES OF RELATIVE DENSITY OF GRANULAR SOILS (GRAVELS, SANDS, AND SILTS) (Ref's 2 & 3)**

| | | | |
|---|---|---|---|
| **Very Loose** | N=0-4** | RD=0-30 | Easily push a ½-inch reinforcing rod by hand |
| **Loose** | N=5-10 | RD=30-50 | Push a ½-inch reinforcing rod by hand |
| **Medium Dense** | N=11-30 | RD=50-70 | Easily drive a ½-inch reinforcing rod |
| **Dense** | N=31-50 | RD=70-90 | Drive a ½-inch reinforcing rod 1 foot |
| **Very Dense** | N>50 | RD=90-100 | Drive a ½-inch reinforcing rod a few inches |

**__N__=Blows per foot in the Standard Penetration Test. In granular soils, with the 3-inch-diameter ring sampler, 140-pound weight, divide the blow count by 2 to get N (Ref 4).

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx


Ref 1: ASTM Designation: D 2487-06, **Standard Classification of Soils for Engineering Purposes** (Unified Soil Classification System).

Ref 2: Terzaghi, Karl, and Peck, Ralph B., **Soil Mechanics in Engineering Practice,** John Wiley & Sons, New York, 2nd Ed., 1967, pp. 30, 341, and 347.

Ref 3: Sowers, George F., **Introductory Soil Mechanics and Foundations: Geotechnical Engineering,** Macmillan Publishing Company, New York, 4th Ed., 1979, pp. 80, 81, and 312.

Ref 4: Lowe, John III, and Zaccheo, Phillip F., **Subsurface Explorations and Sampling,** Chapter 1 in "Foundation Engineering Handbook," Hsai-Yang Fang, Editor, Van Nostrand Reinhold Company, New York, 2nd Ed, 1991, p. 39.


## SOIL TERMINOLOGY

## WEATHERING DESCRIPTORS

Fresh — No discoloration, not oxidized, no separation, hammer rings when crystalline rocks are struck.

Slight — Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull, no visible separation, hammer rings when crystalline rocks are struck, body of rock not weakened.

Moderate — Discoloration extends from fractures, usually throughout; Fe-Mg materials are "rusty", feldspar crystals are "cloudy", all fractures are discolored or oxidized, partial separation of boundaries visible, texture generally preserved, hammer dose not ring when rock is struck, body of rock is slightly weakened.

Intense — Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation, all fracture surfaces are discolored or oxidized, surfaces friable, partial separation, texture altered by chemical disintegration, dull sound when struck with hammer, rock is significantly weakened.

Decomposed — Discolored or oxidized throughout, but resistant mineral such as quartz may be unaltered, all feldspars and Fe-Mg minerals are completely altered to clay, complete separation of grain boundaries, resembles a soil, partial or complete remnant of rock structure may be preserved, can be granulated by hand, resistant minerals such as quartz may be present as "stringers" or "dykes".

## BEDDING FOLIATION AND FRACTURE SPACING DESCRIPTORS

| Millimeters | Feet | Bedding | Fracture Spacing |
|---|---|---|---|
| >10 | <0.03 | Laminated | Very Close |
| 10-30 | 0.03-0.1 | Very Thin | Very Close |
| 30-100 | 0.1-0.3 | Thin | Close |
| 100-300 | 0.3-1 | Moderate | Moderate |
| 300-1000 | 1-3 | Thick | Wide |
| 1000-3000 | 3-10 | Very Thick | Very Wide |
| >3000 | >10 | Massive | Extremely Wide |

## ROCK HARDNESS/STRENGTH DESCRIPTORS*

Extremely Hard — Core, fragment, or exposure cannot be scratched with knife or sharp pick; can only be chipped with repeated heavy hammer blows.

Very Hard — Cannot be scratched with knife or sharp pick. Core or fragment breaks with repeated heavy hammer blows.

Hard — Can be scratched with knife or sharp pick with difficulty (heavy pressure). Heavy hammer blow required to break specimen.

Moderately Hard — Can be scratched with knife or sharp pick with light or moderate pressure. Core or fragment breaks with moderate hammer blow.

Moderately Soft — Can be grooved $^{1}/_{16}$ inch (2mm) deep by knife or sharp pick with moderate or heavy pressure. Core fragment breaks with light hammer blow or heavy manual pressure.

Soft — Can be grooved or gouged easily by knife or sharp pick with light pressure, can be scratched with fingernail. Breaks wit light to moderate manual pressure.

Very Soft — Can be readily indented, grooved, or gouged with fingernail, or carved with a knife. Breaks with light manual pressure.

*Note: Although "sharp pick" is included in those definitions, descriptions of ability to be scratched, grooved, or gouged by a knife is the preferred criteria.

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"Engineering Geology Field Manual, Second Edition, Volume 1, by U.S. Department of Interior, Bureau of Reclamation, 1998

# ROCK TERMINOLOGY

## GENERAL NOTES FOR BORING LOGS:

The boring logs are intended for use only in conjunction with the text, and for only the purposes the text outlines for our services. The Plate "Soil Terminology" defines common terms used on the boring logs.

The plate "Unified Soil Classification System," illustrates the method used to classify the soils. The soils were visually classified in the field; the classifications were modified by visual examination of samples in the laboratory, supported, where indicated on the logs, by tests of liquid limit, plasticity index, and/or gradation. In addition to the interpretations for sample classification, there are interpretations of where stratum changes occur between samples, where gradational changes substantively occur, and where minor changes within a stratum are significant enough to log.

There may be variations in subsurface conditions between borings. Soil characteristics change with variations in moisture content, with exchange of ions, with loosening and densifying, and for other reasons. Groundwater levels change with seasons, with pumping, from leaks, and for other reasons. Thus boring logs depict interpretations of subsurface conditions only at the locations indicated, and only on the date(s) noted.

## SPECIAL FIELD NOTES FOR THIS REPORT:

1. The borings were drilled on May 23 and December 28, 2017, with a portable, minuteman, drilling rig using 4-inch diameter solid flight augers. The borings were backfilled with cement grout following completion of the subsurface explorations.

2. The boring locations were approximately located by using a tape measure and/or pacing from known points on the site, as shown on Plate 2, Site Plan.

3. The soils' Group Names [e.g. SANDY LEAN CLAY] and Group Symbols [e.g. (CL)] were determined or estimated per ASTM D 2487-06, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System, see Plate 11). Other soil engineering terms used on the boring log are defined on Plate 12, Soil Terminology. Engineering geologic terms used to describe bedrock conditions are defined on Plate 13, Rock Terminology

4. The "Blow Count" Column on the boring logs indicates the number of blows required to drive the sampler below the bottom of the boring, with the blow counts given for each 6 inches of sampler penetration. The samples from the boring were driven with a 140-pound hammer.

5. Groundwater was encountered in Boring B-1, at a depth of approximately 13½ feet below the existing ground surface. Groundwater was not encountered in any of the other borings drilled for this investigation.

6. The shear strength values indicated on the boring logs are peak strength values.

BORING LOG NOTES

# KEY TO SYMBOLS

| Symbol | Description |
|---|---|

**Strata symbols**

- Lean clay with sand
- Serpentinite
- Sandy lean clay
- Franciscan Formation Greenstone
- Lean Clay
- Sandstone
- Aggregate Base
- Franciscan Melange

**Misc. Symbols**

- Water level at completion of boring
- Drilling refusal

**Soil Samplers**

- Modified California Sampler: 2.375" ID by 3" OD, split-barrel sampler driven w/ 140-pound hammer falling 30 inches
- California Sampler: 1.875" ID by 2.5" OD, split-barrel sampler driven w/ 140-pound hammer falling 30 inches

| Symbol | Description |
|---|---|

- Standard Penetration Test: 1 3/8" ID by 2" OD, split-spoon sampler driven with 140-pound hammer falling 30" (ASTM D 1586-99)

**Line Types**

| Symbol | Description |
|---|---|
| ______ | Denotes a sudden, or well identified strata change |
| _ _ _ | Denotes a gradual, or poorly identified strata change |

**Laboratory Data**

| Symbol | Description |
|---|---|
| DS | Direct shear test performed on a sample at natural or field moisture content (ASTM D2166). |
| DSX | Direct shear test performed after the sample was submerged in water until volume changes ceased (ASTM D2166). |
| PI | Plasticity Index established per ASTM D4318 Test Method. |
| LL | Liquid Limit established per ASTM D4318 Test Method. |
| AC | Asphaltic concrete |
| AB | Aggregate base |

# BORING LOG

Boring No. B-1

BVGG ENGINEERS

*JOB NAME:* Seneca Lane Slide Repair
*CLIENT:* BKF Engineers
*LOCATION:* West of upper scarp
*DRILLER:* Access Soil Drilling
*DRILL METHOD:* Portable Minuteman

*JOB NO.:* BKFEN-34-00
*DATE DRILLED:* May 23, 2017
*ELEVATION:* 337± feet
*LOGGED BY:* EW

| Type of Strength Test | Test Surcharge Pressure, psf | Test Water Content, % | Shear Strength, psf | In-Situ Water Content, % | In-Situ Dry Unit Weight, pcf | Depth, ft. | Soil Symbols, Samplers and Blow Counts | USCS | Description | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 5, 6, 5 | CL | LEAN CLAY WITH SAND: brown, stiff, moist, well-graded sand, trace fine gravel | Fill |
| DSX<br>DSX | 320<br>1500 | 24.8<br>21.3 | 574<br>1858 | 18.4<br>18.0 | 100<br>105 | | | | | LL=45<br>PI=24 |
| | | | | | | 2.5 | 6, 7, 9 | | ...mottled brown, red-brown and olive-brown, stiff, moist, well-graded sand, trace fine gravel, scarce coarse gravel | |
| DSX<br>DSX | 500<br>2000 | 24.1<br>25.0 | 1117<br>1943 | 23.0<br>24.3 | 101<br>98 | | | | | |
| | | | | | | 5 | 15, 13, 15 | | ...mottled gray-brown and yellow-brown with trace blue-gray, very stiff, moist, few fine sand, trace medium to coarse sand, trace gravel size bedrock fragments, trace roots | |
| DS<br>DS | 700<br>2500 | Nat.<br>Nat. | 1632<br>2511 | 22.5<br>23.0 | 98<br>100 | | | | | |
| | | | | | | 7.5 | 6, 8, 12<br>9, 11, 12 | CL | LEAN CLAY WITH SAND: dark yellow-brown, stiff, slightly moist, fine sand, trace medium to coarse sand and fine gravel | Native |
| | | | | | | 10<br>12.5 | 10, 15, 24<br>24, 27, 43 | sp | SERPENTINITE?: olive-brown to light olive-gray, very moist, decomposed to very stiff sandy clay matrix, trace fine angular gravel | |
| | | | | | | 15 | | | The boring was terminated at approximately 14 feet bgs. Groundwater was encountered at approximately 13½' bgs. | The borehole was backfilled with cement grout. |

# BORING LOG

Boring No. B-2

BAGG ENGINEERS

*JOB NAME:* Seneca Lane Slide Repair
*CLIENT:* BKF Engineers
*LOCATION:* Center of slide mass
*DRILLER:* Access Soil Drilling
*DRILL METHOD:* Portable Minuteman

*JOB NO.:* BKFEN-34-00
*DATE DRILLED:* May 23, 2017
*ELEVATION:* 318± feet
*LOGGED BY:* EW

| Type of Strength Test | Test Surcharge Pressure, psf | Test Water Content, % | Shear Strength, psf | In-Situ Water Content, % | In-Situ Dry Unit Weight, pcf | Depth, ft. | Soil Symbols, Samplers and Blow Counts | USCS | Description | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 2, 1, 2 | CL | LEAN CLAY: gray-brown, soft, moist to very moist, some sand | Mudslide Debris |
| | | | | | | 2.5 | 3, 3, 4 | | ...red-brown, medium stiff, moist, well-graded sand<br>...brown with trace blue-gray mottling | |
| | | | | | | 5 | 6, 9, 13 | | ...brown and red-brown | |
| | | | | | | 7.5 | 8, 13, 16 | | | |
| | | | | | | | 25, 26, 30 | sp | SERPENTINITE: olive- to yellow-brown, moist, decomposed to very stiff sandy clay matrix | Basal Slide Plane |
| | | | | | | 10 | 19, 25, 30 | KJfg | FRANCISCAN FORMATION GREENSTONE: reddish-brown, very moist, decomposed to very stiff sandy clay matrix | |
| | | | | | | 12.5 | 24, 24, 23 | | | |
| | | | | | | 15 | | | The boring was terminated at approximately 14 feet bgs. Groundwater was not encountered in the boring. | The borehole was backfilled with cement grout. |

# BORING LOG

Boring No. B-3

BVGG ENGINEERS

*JOB NAME:* Seneca Lane Slide Repair
*CLIENT:* BKF Engineers
*LOCATION:* South-central portion of slide mass
*DRILLER:* Access Soil Drilling
*DRILL METHOD:* Portable Minuteman

*JOB NO.:* BKFEN-34-00
*DATE DRILLED:* May 23, 2017
*ELEVATION:* 315± feet
*LOGGED BY:* MM

| Type of Strength Test | Test Surcharge Pressure, psf | Test Water Content, % | Shear Strength, psf | In-Situ Water Content, % | In-Situ Dry Unit Weight, pcf | Depth, ft. | Soil Symbols, Samplers and Blow Counts | USCS | Description | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 2, 2, 2 | CL | LEAN CLAY WITH SAND: dark yellow-brown, very moist, soft, contains fine sand, trace gravel | Mudslide Debris |
| | | | | | | 2.5 | 4, 8, 8 | | ...stiff | |
| | | | | | | 5 | 6, 3, 8 | | | |
| | | | | | | 7.5 | 6, 6, 4 | | ...very moist, soft to medium stiff zone from 7½ to 8 feet | |
| | | | | | | | 12, 18, 24 | sp | SERPENTINITE: olive-brown, very moist, decomposed to very stiff sandy clay matrix, trace fine angular gravel, highly oxidized | Basal Slide Plane |
| | | | | | | 10 | 13, 17, 29 | | | |
| | | | | | | 12.5 | 25, 30, 50/6" | | | |
| | | | | | | 15 | | | The boring was terminated at approximately 14 feet bgs. Groundwater was not encountered in the boring. | The borehole was backfilled with cement grout. |

# BORING LOG

Boring No. B-4

BAGG ENGINEERS

*JOB NAME:* Seneca Lane Slide Repair
*CLIENT:* BKF Engineers
*LOCATION:* Upper mudslide scarp
*DRILLER:* BAGG
*DRILL METHOD:* Hand Auger and Portable Sampling Equipment

*JOB NO.:* BKFEN-34-00
*DATE DRILLED:* May 23, 2017
*ELEVATION:* 333± feet
*LOGGED BY:* EW

| Type of Strength Test | Test Surcharge Pressure, psf | Test Water Content, % | Shear Strength, psf | In-Situ Water Content, % | In-Situ Dry Unit Weight, pcf | Depth, ft. | Soil Symbols, Samplers and Blow Counts | USCS | Description | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | | sp | SERPENTINITE: yellow- to dark yellow-brown, very moist, decomposed to stiff sandy lean clay matrix with trace angular gravel | Mudslide Scarp |
| DSX | 1000 | 25.4 | 945 | 23.6 | 98 | | 23 | | | LL=40 |
| DSX | 2400 | 24.2 | 1575 | 22.6 | 99 | | 32 | | | PI=25 |
| DS | 1200 | Nat. | 1830 | 16.5 | 111 | 2.5 | 25 | | | |
| DS | 3600 | Nat. | 2794 | 18.0 | 105 | | 50/3" | | | |
| DS | 1300 | Nat. | 1802 | 13.8 | 108 | | 35 | | | |
| DS | 4000 | Nat. | 2766 | 16.1 | 110 | | 50/2" | | | |
| | | | | | | 5 | | | The boring was terminated at approximately 3.75 feet bgs. Groundwater was not encountered in the boring. Immediately after the last sample was retrieved, the borehole was backfilled with cement grout. | |
| | | | | | | 7.5 | | | | |
| | | | | | | 10 | | | | |
| | | | | | | 12.5 | | | | |
| | | | | | | 15 | | | | |

# BORING LOG

Boring No. B-5

BAGG ENGINEERS

*JOB NAME:* Seneca Lane Slide Repair
*CLIENT:* BKF Engineers
*LOCATION:* Lower mudslide scarp
*DRILLER:* BAGG
*DRILL METHOD:* Hand Auger and Portable Sampling Equipment

*JOB NO.:* BKFEN-34-00
*DATE DRILLED:* May 23, 2017
*ELEVATION:* 316± feet
*LOGGED BY:* EW

| Type of Strength Test | Test Surcharge Pressure, psf | Test Water Content, % | Shear Strength, psf | In-Situ Water Content, % | In-Situ Dry Unit Weight, pcf | Depth, ft. | Soil Symbols, Samplers and Blow Counts | USCS | Description | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | | KJfg | FRANCISCAN FORMATION GREENSTONE: yellow-brown, very moist, decomposed to sandy lean clay matrix, trace fine angular gravel | Mudslide Scarp |
| DSX<br>DSX<br>DS | 800<br>2100<br>3000 | 20.7<br>22.2<br>Nat. | 1261<br>1490<br>2892 | 20.7<br>19.3<br>11.2 | 107<br>104<br>113 | 2.5 | 40<br>50/6" | | | |
| | | | | | | 5 | | | The boring was terminated at approximately 3 feet bgs. Groundwater was not encountered in the boring. Immediately after the last sample was retrieved, the borehole was backfilled with cement grout. | |
| | | | | | | 7.5 | | | | |
| | | | | | | 10 | | | | |
| | | | | | | 12.5 | | | | |
| | | | | | | 15 | | | | |

BvGG ENGINEERS

# BORING LOG

Boring No. B-6

*JOB NAME:* Seneca Lane Slide Repair
*CLIENT:* BKF Engineers
*LOCATION:* East portion of slide mass
*DRILLER:* West Coast Exploration
*DRILL METHOD:* Continuous Sampling

*JOB NO.:* BKFEN-34-00
*DATE DRILLED:* Dec. 28, 2017
*ELEVATION:* 315± feet
*LOGGED BY:* EW

| Type of Strength Test | Test Surcharge Pressure, psf | Test Water Content, % | Shear Strength, psf | In-Situ Water Content, % | In-Situ Dry Unit Weight, pcf | Depth, ft. | Soil Symbols, Samplers and Blow Counts | USCS | Description | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 1, 1, 2, 1, 1, 3 | CL | LEAN CLAY WITH SAND: brown to gray-brown, very soft, very moist, well- graded sand, trace gravel, contains roots and rootlets<br>...reddish-brown, medium stiff, moist, fine to medium sand, trace coarse sand | Slide Debris |
| DSX<br>DSX | 320<br>1000 | 28.0<br>28.0 | 489<br>745 | 27.8<br>27.2 | 91<br>93 | 2.5 | 3, 3, 4, 4 | CL | LEAN CLAY: light brown to orange-brown, medium stiff, moist to very moist, trace fine to medium sand | |
| DSX<br>DSX | 600<br>1500 | 31.1<br>30.8 | 574<br>716 | 29.1<br>31.0 | 89<br>86 | 5 | 5, 6, 5, 5 | | ...light brown with trace orange-brown and gray, moist, few fine to medium sand, trace coarse sand and fine gravel, trace rootlets | |
| DSX<br>DSX | 850<br>1800 | 20.7<br>23.2 | 1089<br>1175 | 18.7<br>21.1<br>5.7 | 105<br>101 | 7.5 | 8, 15, 40 | CL | SANDY LEAN CLAY: mottled brown, gray-brown and yellow-brown, stiff, moist, fine sand, trace medium to coarse sand | Decomposed Bedrock |
| | | | | 7.6 | | | 69/6", 72/6", 75/6" | ROCK | FRANCISCAN FORMATION SANDSTONE: olive-gray to yellow-brown, moderately to intensely weathered, moderately soft, closely fractured | |
| | | | | | | 10 | | | The boring encountered practical refusal at approximately 10 feet bgs.<br>Groundwater was not encountered in the boring.<br>Immediately after the last sample was retrieved, the borehole was backfilled with cement grout. | |
| | | | | | | 12.5 | | | | |
| | | | | | | 15 | | | | |

# BORING LOG

Boring No. B-7

BVGG ENGINEERS

*JOB NAME:* Seneca Lane Slide Repair
*CLIENT:* BKF Engineers
*LOCATION:* Access road adjacent to west portion of slide mass
*DRILLER:* West Coast Exploration
*DRILL METHOD:* Continuous Sampling

*JOB NO.:* BKFEN-34-00
*DATE DRILLED:* Dec. 28, 2017
*ELEVATION:* 320± feet
*LOGGED BY:* EW

| Type of Strength Test | Test Surcharge Pressure, psf | Test Water Content, % | Shear Strength, psf | In-Situ Water Content, % | In-Situ Dry Unit Weight, pcf | Depth, ft. | Soil Symbols, Samplers and Blow Counts | USCS | Description | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 16<br>11 | | WELL-GRADED SAND WITH SILT & GRAVEL: dark gray, medium dense, slightly moist to moist, well-graded sand, few angular gravel | Aggregate Base |
| DSX | 320 | 25.6 | 688 | 16.2 | 99 | | 16<br>22 | CL | | Fill |
| | | | | | | 2.5 | 20<br>28 | | LEAN CLAY: brown, very stiff, slightly moist, trace fine sand, trace rootlets | |
| DSX | 1000 | 27.8 | 1745 | 26.7 | 100 | | 30<br>32 | | ...brown, very stiff to hard, moist, trace to few fine to medium sand, trace coarse sand | |
| DSX | 1250 | 24.9 | 2114 | 18.9 | 105 | | 18 | CL | LEAN CLAY WITH SAND: brown with trace yellow-brown and gray-brown, hard, slightly moist, fine to medium sand, trace coarse sand and fine gravel | Native |
| | | | | | | 5 | 25<br>36 | | | |
| | | | | 9.3 | | | 52 | CL | SANDY LEAN CLAY: mottled gray-brown, brown, and orange-brown, hard, slightly moist, well-graded sand, trace toi few fine gravel | Decomposed Bedrock |
| | | | | 15.3 | 92 | | 60/6" | KJfg | FRANCISCAN FORMATION GREENSTONE: yellow brown with trace dark gray, intensely weathered, moderately soft, very closely fractured with clay infill | |
| | | | | 20.6 | 106 | | 33 | | | |
| | | | | | | 7.5 | 46<br>70 | | | |
| | | | | 6.7 | | | 56<br>66/6" | | ...gray and brown, moderately weathered, moderately hard | |
| | | | | | | 10 | | | The boring encountered practical refusal at approximately 9 feet bgs. | |
| | | | | | | 12.5 | | | Groundwater was not encountered in the boring. | |
| | | | | | | 15 | | | Immediately after the last sample was retrieved, the borehole was backfilled with cement grout. | |

# BORING LOG

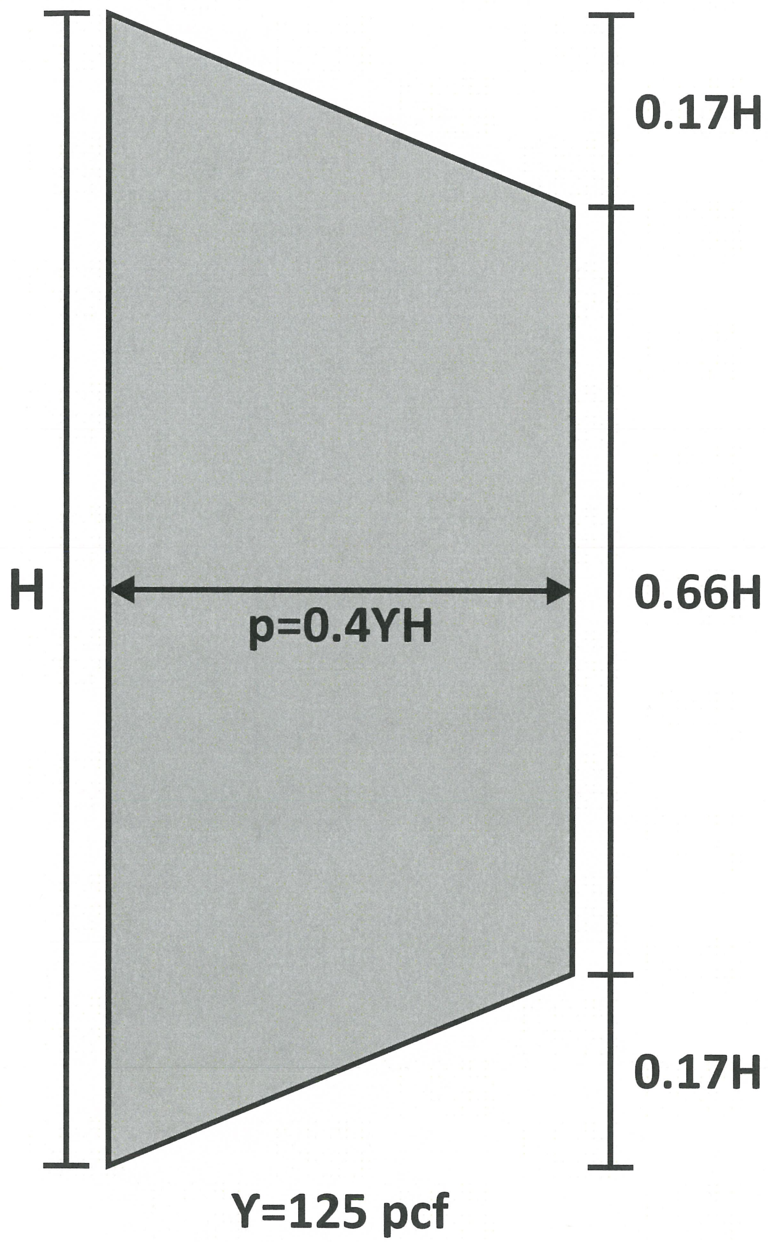
Boring No. B-8

BAGG ENGINEERS

*JOB NAME:* Seneca Lane Slide Repair
*CLIENT:* BKF Engineers
*LOCATION:* Access road ≅ 100'southwest of existing sewer manhole
*DRILLER:* West Coast Exploration
*DRILL METHOD:* Continuous Sampling

*JOB NO.:* BKFEN-34-00
*DATE DRILLED:* Dec. 28, 2017
*ELEVATION:* 322± feet
*LOGGED BY:* EW

| Type of Strength Test | Test Surcharge Pressure, psf | Test Water Content, % | Shear Strength, psf | In-Situ Water Content, % | In-Situ Dry Unit Weight, pcf | Depth, ft. | Soil Symbols, Samplers and Blow Counts | USCS | Description | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 11, 18, 21, 28 | CL | LEAN CLAY WITH SAND: brown to reddish-brown, very stiff, moist, fine to medium sand, trace coarse sand | Fill |
| | | | | | | 2.5 | 26, 30, 35, 38 | CL | SANDY LEAN CLAY: red-brown with trace yellow-brown, hard, moist, fine to medium sand, trace coarse sand | Native |
| | | | | | | 5 | 25, 34, 38, 45 | | ...mottled brown, yellow-brown and orange-brown, slightly moist, well-graded sand, trace gravel | Decomposed Bedrock |
| | | | | | | 7.5 | 17, 17, 30, 52 | KJm | FRANCISCAN FORMATION MELANGE: dark gray, intensely to moderately weathered, soft | |
| | | | | | | | 99/6" | | ...moderately weathered, contains clasts of graywacke sandstone | |
| | | | | | | 10 | | | The boring encountered practical refusal at approximately 8½ feet bgs. Groundwater was not encountered in the boring. Immediately after the last sample was retrieved, the borehole was backfilled with cement grout. | |
| | | | | | | 12.5 | | | | |
| | | | | | | 15 | | | | |




**Reference**: State of California Department of Transportation Trenching and Shoring Manual, Revision 1, Issued by Offices of Structure Construction, August 2011

| | |
|---|---|
| SUPPLEMENTAL GEOTECHNICAL ENGINEERING INVESTIGATION<br>SENECA LANE MUDSLIDE<br>SEWER STABILIZATION PROJECT<br>SAN MATEO COUNTY, CALIFORNIA | **REPRESENTATIVE EARTH PRESSURE DIAGRAM**<br>DATE: January 2018 · JOB NUMBER: BKFEN-34-00 · PLATE 20 |

BAGG ENGINEERS